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ABSTRACT

This document reports the working papers of a research project designed to develop quantitative management techniques applicable to the university environment. The University of Copenhagen was selected as the target institution for the research. Presentation of the papers is divided into four parts: introduction, general information and overview of the University of Copenhagen, governmental agencies, and the desired university structure. Topics include an introduction and summary of findings; higher education in Denmark; the University of Copenhagen - illustration of some problems; budgeting, economic management and planning at the Ministry of Finance; the Ministry of Education as a planning agency; simulation model of a university; decentralized planning in a university system; moving decisions between management levels with conflicting objectives; the development of a decisionmaking process; and a postscript on decision structure. The appendix includes the English summary of working reports and papers June 1971 and an index. (MJM)

ED 076100

Centre for Educational Research and Innovation (CERI)

STUDIES IN INSTITUTIONAL MANAGEMENT
IN HIGHER EDUCATION

UNIVERSITY OF COPENHAGEN

DECISION, PLANNING AND BUDGETING

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1972

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PREFACE

In CERI's Programme on Institutional Management in Higher Education, eight universities were brought together to set up teams within their institutions to work on their respective pre-selected problem areas. (1) These teams have worked over varying lengths of time, none of which exceeded two years. The results of their work, together with the results of the in-house research of the Secretariat was presented before a wide audience of university executives and managers and Government representatives from the OECD Member countries at an Evaluation Conference held in Paris on 2nd-5th November, 1971.

The Programme's work has now produced analyses of the major problem areas of university management and the general directions in which solutions to these problems must be sought. By concentrating the effort in selected university environments the approaches developed may not have the attraction of generality, but this has been more than offset by the demonstration of concrete ways of tackling the specific problems of university management.

This effort represents significant contributions in, at least, four areas :

First, conscious of the fact that universities have become major consumers of financial resources, it has been possible to indicate methods for evaluating the requirements of resources and their costs not only for the university as a whole but especially for its different components. This has involved the use of the budget as a planning tool by linking the expenditures, as far as possible, to the objectives of the programmes for which these expenditures have been incurred.

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1) These universities are the Free University of Berlin, University of Bradford, University of Copenhagen, Chalmers University of Technology, Gothenburg University of Lancaster, University of Nijmegen, University of Novi Sad, Université de Paris X-Nanterre. The University of Copenhagen project was, however, carried out by a team from the Technical University of Denmark.

Second, it has been possible to demonstrate the costs and the consequences of different decisions concerning selected university matters both for current operations and for expansion, in order that policy-makers may choose desired courses of action. Such an approach offers an opportunity for effectively reducing the arbitrariness of decisions concerning the allocation of resources, and thereby improving the general efficiency of operations.

Third, from early in the development of the programme it was found that the basic information requirement for university-wide management was either lacking or was too dispersed among various bodies for its effective utilization by decision-makers. It was possible, in the programme, to carry out pilot exercises not only to determine information availability and requirements, but also to propose the creation of an information base within the university geared to the needs of the decision-makers.

Four, computer-based mathematical techniques and models have been constructed and tested to demonstrate their potential usefulness in providing a range of results quickly and efficiently, not only for the specific problems of the university for which they were constructed, but also for similar problems in a large number of different universities.

The studies carried out so far have clearly demonstrated that despite great diversity of environment in which the university functions and the variety in the pattern of their organisation, they nevertheless share common problems which can be tackled through inter-institutional/international effort.

The Danish report is the result of a project initiated in 1969 by agreement between the Danish Ministry of Education and the OECD Centre for Educational Research and Innovation. The aim of the research project was to develop a planning and control system for the University of Copenhagen, with the view to its general applicability. A financial contribution to the project was made by Shell Denmark by agreement with the OECD.

Dr. Arne Jensen directed the team set-up at the Technical University of Denmark. All chapters in the report are published in the names of the research workers who undertook the particular aspects of the research.

Additional findings have been published separately in the OECD Technical Report entitled University Decision Structures. (1)

Dr. Abdul G. Khan was the staff member responsible for the CERI Programme on Institutional Management in Higher Education, and as such has played an overall coordinating role for the whole Programme. He was assisted by Dr. Paul M. LeVasseur.

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1) A. Jensen, R. Jurkovich, J. Halpern, University Decision Structures, OECD, Centre for Educational Research and Innovation, Paris, 4th November, 1972.

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PART I

INTRODUCTION
AND
SUMMARY OF FINDINGS

Chapter 1

INTRODUCTION AND SUMMARY OF FINDINGS

by

Arne Jensen

The problems facing our institutions of higher education are by no means a unique Danish problem. The rapid increase in the influx of students to the universities and the simultaneous growing scarcity of resources have necessitated a continuous and greater effort to improve the planning and resource allocation techniques.

The results obtained and the methods developed by the research team are not eternal truths, which, if applied at any time, will lead to improvements. Modern management techniques are continuously modified and improved in accordance with our increased knowledge. It must also be emphasized that several local problems have been incorporated in the work. On this count the results may suffer somewhat in general applicability. The results presented in this report are however our best estimate of those methods which in our opinion can be readily adopted and successfully implemented.

The research activity has been carried out by a group of 6 people with very different academic backgrounds, ranging from Industrial Engineering, Economics, to Sociology. The members of the research team were not only selected to have different educational backgrounds, but also to have different work experiences. One group member was borrowed from the planning department of the Ministry of Finance. Another had worked part-time in the department of higher education of the Ministry of Education. Two were faculty members at the Technical University of Denmark. The two final group members were both foreign research workers with experience in similar work elsewhere. Quite by accident we discovered that several team members previously had held important positions with some of the most influential student unions.

Niels Hammer-Jespersen has a Masters degree in Economics; he graduated from the University of Copenhagen, Jan. 1970. He is working half time in the Ministry of Education as a staff member in the Planning and Budgeting Department.

Jens N. Christiansen has a Masters degree in Economics; he graduated from the University of Aarhus in Jan. 1970. He has been student representative in several public commissions on education. He works part time on the CERI project and he is a staff member of the planning group of the Ministry of Finance.

Bo Munch-Andersen has a Masters degree in Electrical Engineering and Operations Research from the Technical University of Denmark, Jan. 1966. He has previously worked in the Defence research department and spent two years with Control Data Corp. in California, before joining the CERI project in 1970.

Hans Jørgen Rasmusen has a Masters degree in Operations Research and Management Science from the Technical University of Denmark, Jan. 1968. He had been working in the National Statistics department before joining IMSOR in 1969, where he has been working on several educational planning problems, as well as other operations research projects.

Jonathan Halpern has been with our project for two months, stopping on his way from Berkeley California to Israel. He wrote his Ph. D. dissertation in 1970 dealing with faculty planning, and he has been working with the Ford Foundation Research group at Berkeley for four years.

Raymond Jurkovich has a Masters degree in Political Science and Public Administration from Berkeley, Sept. 1968. He has been with the CERI project for 6 months in 1970. He has previously worked on modernization and development research for the developing nations.

The diversification was adopted in order to secure a broad and general attack on the problems. An informal steering committee was established to supplement the research team. This committee represented the Ministry of Education and various offices of the administration of the University of Copenhagen. The main purpose of this committee was to provide the research team members with possibilities of access to various decision-making bodies of the University, as well as to provide a forum for discussion of the research work and results.

Members of the steering committee were Mrs. Berrit Hansen, Mrs. Lilian Vohn and Mr. H. Puggard Nielsen, all staff members from the Ministry of Education; Mr. O. Høffding, Mr. Hans Myltoft from the economic administration of the University of Copenhagen; Mr. P. V. Olters and Mr. John A. Sørensen from the data processing division of the academic administration of the University of Copenhagen. Professor Erling Olsen and Mr. Børge Klemmensen represented the faculty and the students of the University. During the project Professor Erling Olsen was nominated Rector for the new University at Roskilde.

The University of Copenhagen was selected as the target institution for our research, primarily because this University appeared to suffer most severely from the rapid expansion in the number of students enrolled.

The project was placed at the Institute of Mathematical Statistics and Operations Research, the Technical University of Denmark, and a total of 18 months were available for our research work. During this time 14 working papers have been issued.

This final report is largely based upon the above mentioned working papers, which implies that this report is composed of several papers, each of which is considered an entity. It may appear that the conclusions of different authors are slightly incongruent and that certain problems appear and are solved in more than one paper.

This should not scare the reader, indeed we have deliberately attempted to devise a number of methods and certainly not a single method.

The goals in this research project can be summarized in terms of the following main issues :

- To show how quantitative techniques can be fruitfully applied in a university environment. From the very beginning of this research project we felt that one of the main causes for the administrative difficulties encountered at the University was a general lack of proper managerial techniques The central decision-makers completely lack the means by which they can compare and coordinate proposals and activities. The number of activities at a modern large-scale university is measured in terms of thousands, yet the decision-making bodies, both at the top and at the bottom, are without any means by which they can obtain a comprehensive view of the system and its future.

- To show how an efficient decentralized planning procedure can be implemented. Decentralized planning is considered advantageous for two very different reasons :

One is that the level of diversification and specialization in a university is so high that, for all practical purposes, it is impossible to create all plans for innovation at the top of the system. Rather, each member must be motivated to develop new ideas upon which innovation can be based. This requires that each member or group of members are given a certain degree of freedom, and that their activity is only controlled through some common parameters.

The other reason is that the amount of data and information required to perform a central control is so large and extensive that even the most versatile computer system can never satisfy the requirements. The errors and the bias, which are a result of highly different objectives among those contributing the data, render the data of questionable value. In a decentralized planning system much less information has to be transmitted between the decision-making bodies.

- To propose a new and improved budgeting and planning procedure. The procedures currently applied have a tendency to mix the strategic and tactic planning phases together. The process also has some very long time - delays built into it. The main implication of these delays is that the departments and institutes of the university, who have the least managerial potential, must operate with the longest planning horizon.

- Finally our goal was to concentrate upon the development of simple decision rules, both in terms of mathematical structure and in terms of data requirement. We do feel that this issue is a crucial issue,because only a few people at a university can be expected to be familiar with the techniques of operations research and management sciences.

Summary of Findings

The main purpose of this research project has been the development of quantitative management techniques applicable in a university environment.

During the 18 months of research activity many things have changed inside and outside the research group. Not only did we, as analysts, continuously increase our knowledge on the way a university works, but the University as well introduced new ideas and innovations. Some of these innovations were undoubtedly due to this research work, but many resulted from creative work of administrators and decision-makers in the educational system.

This knowledge may post festum suggest that the research activity should have followed a different path of evolution. During the research activity it was learned that some of the current managerial difficulties seem to be a result of an unsuitable organization rather than a result of insufficient managerial techniques. However organizational improvements and innovations can never be successfully introduced with insufficient managerial tools.

Our research work is not the only work currently underway, and it is interesting to note that many of the conclusions we have arrived at are highly congruent with those published elsewhere.

Professor Oliver, Professor Balderston and Professor Weathersby, of the Ford Foundation sponsored Research Program in University Administration at the University of California, Berkeley, have among others developed many interesting methods. Professor Ackoff of the University of Pennsylvania has also been dealing with several important issues related to this area of research.

The first usable result of our own work is the development of two readily applicable models. One is a forecasting type simulation model - a model particularly developed to determine the consequences of actions of various sorts.

The other is a decentralized resource allocation model and procedure - a model particularly developed to recommend a specific action to be taken in order to solve a problem.

Both models are designed to be compatible in terms of input data requirement and system structure. Both models attempt to simulate one educational institution and both assume that the institution can be subdivided into several sectors, each operating relatively independent of the others. As a matter of simplicity only two levels are dealt with in the presentations.

A further two models have been developed, but not yet to a stage of immediate implementation. One deals with the possible use of earmarking of resources in planning and the other deals with a procedure applicable to the control of resource allocations in cases where central coordination has to be reduced to a minimum.

The simulation model (Part IV, Chapter 6) is based upon two flow models, one describing the flow of students and the other describing the flow of faculty members. The student flow model has one sector for each of the main areas of study at the University, and the number of grades is chosen so that approximately 97% of a cohort of students, distributed in one-year intervals, are represented by the model.

Two additional grades are employed, one counting the drop-outs and the other counting the graduates. The underlying flow matrix has been estimated using real data from the University of Copenhagen.

The transition coefficients of the faculty flow model have been estimated using life tables and an estimation of the distribution of service time for tenure faculty members. The promotion rules correspond to those currently proposed in Denmark. Both flow models use a time base of one year.

Based upon the forecasted new enrolments, the student flow model computes the distribution of students on the various grades. The required number of teachers is computed for each of the future time periods using sector-wise student/teacher ratios. The faculty flow model computes the supply of teachers in each sector. If any demand does exist, the necessary number of teachers is hired into the youngest age grade of the model.

The simulation model has further been developed to compute the resulting salary and overhead costs for each of the sectors and each of the years in the forecasting period.

The main purpose of this forecasting type simulation model is to provide a tool for a rapid, comprehensive evaluation of the future consequences, in terms of total cost and manpower requirements, of the introduction of, for instance, a new curriculae, smaller class sizes, a different promotion scheme for the faculty, improved student/teacher ratios and so on. All these are issues of great importance in strategic planning and in the formulation of feasible long-term goals.

The model assumes that a central university-wide data base can provide the necessary student and faculty flow data, and relevant costs data. The model operates in a deterministic way.

That is, no uncertainty appears in the model. All parameters are assumed to have fixed, but replaceable values which can be controlled and modified in the course of the planning process. The model has been developed and programmed by Niels Hammer-Jespersen.

The decentralized planning model (Part IV, Chapter 7) has been designed primarily as a tactical resource allocation tool These decisions are in general characterized by a general lack of resources and by incomplete information. The general lack of resources implies that the most pronounced demands must be satisfied first. Thus one purpose of this planning model is to present the decision-maker with one particularly good way in which he can allocate the available liquid resources in order to obtain the best overall achievements.

The problem of incomplete information is circumvented by the introduction of a decentralized decision-making system,in which the central decision-maker only deals with total costs and total achievements and highly aggregated decision variables, but not with the individual projects, which are left to the decentralized leaders to select.

The problem is formulated as a linear programming problem covering all four years of the current budgeting period. The central decision-maker solves a master model, from which he receives information on the proper resource quotas, which he shall allocate to each sector.

Each sector subsequently solves their own decentralized model covering their activities. Each decentralized sector responds to the resources received in terms of the associated shadow-prices. (A measure indicating how much the plan will be improved if one more unit of resource is made available).

The final (optimal) resource allocation is reached through a series of iterations, in which the central decision-maker reallocates the resources until all sectors show equal values of the shadow prices.

The central master model is introduced in order to permit the central decision-maker to validate the shadow-prices he receives from the decentralized sectors. In fact the sectors need not have their own model, they may choose to respond by other means. The master model does however provide the central decision-maker with an efficient means to compare resource use and requirements from the sectors.

The planning inputs are the future expected teaching demands for each of the sectors, the future expected total resource quotas or ceilings available to the university and finally the current (initial) distribution of tenure and non-tenure teachers. The output is the allocation for each planning period of tenure and non-tenure positions that best satisfies the overall teaching demands, considering that the cost and productivity per tenure and non-tenure position varies from one sector to another, as well as that different possibilities of substitution between tenure and non-tenure teaching exist.

These differences are mainly a result of the different research and teaching policies and goals adopted by the faculties of the universities. The model provides the decision-maker with a tool that readily can devise the optimal resource allocation for the entire planning horizon each time resource ceilings are changed. The model can equally well determine the best resource allocation if one or more of the teaching demands are developing differently from what had been anticipated.

The model can finally be used to evaluate how the resource allocations are affected if one sector wants to introduce an innovation which will affect the unit cost or productivity of the manpower positions. The model has been developed and programmed by Hans Jørgen Rasmusen.

The application of earmarking of resources has been studied by Bo Munch-Andersen (Part IV, Chapter 8).

A model has been developed for analyzing the effect of moving decisions from one level of university management to another.

The decisions considered are the allocation of two types of resources, manpower and money, to a set of activities. The two levels of management are assumed to have different preferences as to the allocation of resources on the activities. In the model the upper level management first allocates a certain portion of the available resources, and subsequently the lower level management allocates the remaining portion of resources. Both managements attempt to minimize the deviation of the resulting combined allocation from their particular preferred allocation.

Changing the upper level portion of available resources from none to all of it, the model calculates the resulting combined allocation and measures for the deviation from the preferred allocations.

The results of this research activity suggest that earmarking of certain amounts of resources might prove to be an efficient way of controlling decentralization, particularly when used as a managerial tool aimed towards a minimization of conflicts resulting from goal-displacement.

The development of a resource allocation procedure, applicable in cases where future demands cannot be forecasted, has been undertaken by Hans Jørgen Rasmusen, (Part IV, Chapter 9). This procedure is based upon the application of past achievements as a performance criteria, and is particularly intended to be used at the institute level of a university, where a considerable latitude in the selection of elective subjects renders it more or less impossible to forecast actual demands, and where there is a considerable degree of freedom to introduce new courses and to drop old ones.

Although yet in a tentative form,this procedure has several advantages,of which the most pronounced is the dramatic reduction of the required data and data-processing system. Rather than requiring demand forecasts for each course and activity, this process only requires that all current and past activities are registrated. The achievements are then measured with the aid of standard work-load rules.

Prior to the model building Hammer-Jespersen and Rasmusen,together with Jens N. Christiansen, Raymond Jurkovich and Dr. Jonathan Halpern,undertook a series of field studies, in order to acquire some general information about the situation at the University of Copenhagen, as well as in the Ministries of Education and Finance. The reports by Mr. Raymond Jurkovich and Dr. Jonathan Halpern are being issued in a separate volume.

Part II of this report deals with the results of our survey of the University of Copenhagen. Among many other things this survey shows that the student/teacher ratio has been essentially constant over the last 15 years. However the teaching loads feel heavier today because of the extensive diversification of teaching activities and because of a steady tendency to apply more and more teacher-consuming educational methods.

We also found that the top decision-making body of the University (the konsistorium) has found it very difficult to coordinate the activities of the five Faculties. The Natural Science Faculty, on the other hand, has been able to use non-tenure teachers as a means to equalize teaching loads. This Faculty also appears to follow a personnel policy which is far more stable and harmonic than that of the University in general.

The number of professional managers at the University is still found to be very low. Most planning at the Faculty and Institute-department levels is performed by professors, who engage in this work more as a matter of necessity than as a matter of interest.

Part III of this report deals with the current planning trends and ideas of the Ministry of Finance and the Ministry of Education.

The most important result of our research in this field is the knowledge we acquired about the planning constraints. The Ministry of Finance introduced a resource ceiling planning system a few years ago, the ultimate purpose of which has been to introduce some aspects of decentralized planning. This planning procedure still suffers from several deficiencies, which must always be expected to go hand in hand with any major innovation.

The most important feature related to our research work is the attempt to approach a state of total planning as well as a tendency towards the application of aggregated decision variables and system parameters.

Further the Ministry of Finance has recently introduced the concept of perspective planning. For the first time all public institutions and agencies were told to work seriously on the development of long-term goals and objectives, as well as to consider the means by which these goals could be attained.

The main deficiency with this work is that quantitative planning techniques have still only very rarely been applied in the planning. The result is that the central decision-makers still lack comprehensive views of the planning sectors, as well as a proper control system.

The result is that the planning is complicated and the decision making is delayed, because of too much unnecessary centralized decision-making.

University Planning

The Danish CERI research project is composed of 3 basic areas of study. The first one, broadly speaking, covers the economic framework within which society today carries out its financial planning.

The second study area deals with the consequences of various kinds of intervention and influences upon the university.

The third study area is an attempt to develop a comprehensive planning model based upon the decentralization ideas expressed by Kornai and Liptak among others. This model is further developed so that it is compatible with the other studies.

The fourth study area is an attempt to investigate the overall consequences of different goals and objectives at different decision levels. The different goals we had in mind were particularly those expressed by students and faculty members.

The last mentioned area of study does, however, have implications that reach much further than the objectives of the project.

From the very beginning the results obtained in the fourth study area were very promising, and I would like to use these results to elaborate upon the relations between society and academic groups, using a generalized version for which only I am responsible.

Let us assume that level one represents the society in general and that level two is the governing boards and committees of the university. Let us further assume that the activities are the institutes and departments to which resources can be allocated in terms of manpower and funds.

Resources may be allocated directly from the society to the institutes, or certain quotas may be allocated to the governing boards of the university, who in turn can reallocate the resources in order to satisfy additional objectives. The amount of resources provided to the universities for free disposal were in earlier times very scarce.

The rapid growth and diversification of the university sector has, however, made the direct control by society more and more complicated.

As a result, the resource quotas provided to the universities for free disposal have been increased during recent years.

With a larger and larger proportion of the total resources being controlled primarily by the universities, the implication is that the universities have increased their autonomy. Today the Danish university system is primarily influenced by some general financial constraints imposed by society. The society has, in addition, maintained its direct influence through the provision of new physical facilities and through the control of the increases in the manpower quotas.

In a period where the growth of the university sector in general has led us to a situation where we, in a not too distant future, will be able to satisfy all essential demands of the society, one can, naturally, raise the question whether or not the current autonomy will lead to acceptable overall results seen from the point-of-view of the society.

A pronounced scarcity of highly-trained manpower in vital sectors of the society, together with an abundance in less essential sectors of the national economy, may easily reintroduce more centralized control of the allocation of the resources from society.

This issue will become even more pronounced in the future when the ethics of academic groups will come under both political and economic pressure.

Thus there are many reasons to deal with the long term game between the society in general and the academic groups of the university. The society can, as I have explained, choose among a set of actions in order to achieve its goals. These strategies range from a highly centralized to a highly decentralized decision-making structure using economic constraints for the total use of different resources.

The universities can in turn choose a strategy that satisfies their own goals. The resulting outcome of this game is thus a combination of the strategy i chosen by society and the strategy j chosen by the universities, which can be expressed in the following decision-table :

$$\begin{array}{cc|c} & & \text{University strategy} \\ & & \ldots j \ldots \\ \hline & \vdots & \\ \text{Society strategy} & i & G_{su}(i, j) \\ & \vdots & \end{array}$$

where the two-dimensional outcome of the game is composed of the sosiety's gain G_s, and the university's gain G_u according to the expression :

$$G_{su}(i, j) = (G_s(i, j)\,,\ G_u(i, j)).$$

The gains not only include economic factors and human factors but also the more general criteria of the system's ability to adapt to change and growth in itself and in the environment.

However, society is only able to change very slowly from one strategy to another, whereas the university can change much more rapidly. This implies that the society must select its strategy with careful consideration of the likely reaction from the university. This game is by no means an ordinary two-person game. Not only must the universities be expected to have much better information about the possible strategies of the society than vice versa, but neither group of "players" can be characterized as being particularly hostile nor particularly friendly towards one another.

We are dealing with a very interesting version of the two-person game. However, much work must still be done in order to reveal all properties of this game.

In our research work we have assumed that the society does not use its knowledge about the likely counter-strategy from the university when allocating its resources, yet the results show extreme solutions can be prevented by simple means, such as direct allocation of earmarked resources.

Further careful studies of this game between the society and the university may suggest ways in which the so-called overproduction and other undesirable results can be avoided without severely affecting the power structure of the system. Even under changed rules for the power balance between society, students and faculty members it may be possible to avoid extreme situations.

In an investigation of this type one must carefully study the relationship between economic freedom and academic freedom, for groups as well as for individuals. The economic freedom, which is essential for the society in order to adapt to changing environmental factors, is by no means indifferent to the ways in which major economic decisions are made. Neither is the academic freedom indifferent to the economic tyranny of colleagues nor to the pedagogical tyranny of the students.

Up to now I have deliberately avoided dealing with the unknown factors. It is, however, necessary to realize that it is essential that major innovations of the educational sector must be implemented if the rapid evolution of the society is not to be delayed. In the past this adaptation has taken place in three different ways : the society has used earmarking as a means to insure that a certain amount of resources reaches a specific sector. The university has allocated its resources in order to see that a well-established number of areas are kept in balance. And, finally, the choices of the students have served as a means of pressure.

Society has only seldom explicitly expressed its preferences towards the outputs from the universities. It has traditionally been left to the universities themselves to define their objectives and to set the standards. It has even frequently been the duty of the university to estimate the demand for the services it is providing. In doing so the universities have more often been looking into the past rather than into the future. The modern, highly sensitive society can no longer live without a strong and direct coordination of all public investments, including the educational investments.

The radical restructuring which is currently taking place within the health and hospital sector cannot be carried out successfully only through the provision of new physical facilities. It is essential that all manpower and recruitment problems are included in the planning. The demand for personnel must be calculated well in advance in order to attract the students and in order to give the universities and other training institutions ample time to train the personnel.

Without too much trouble society can state five to seven years in advance the number of new jobs of various kinds that will be demanded, and then let the students choose their studies accordingly. The major industries can apply the same policy, as well.

The resulting investment errors are of a magnitude which the society, by and large, always must live with.

Those who do not follow the advice may be those who are particularly suited to deal with the unexpected jobs.

This way of dealing with the uncertainty about the future demands is only one among many possible approaches. People with more imagination and political flair will definitely be able to suggest other alternatives.

A continued research and development activity within the area mentioned will soon be able to shed more light upon the game between the society and the universities. This research work will further be able to devise ways and means to strengthen planning.

With these remarks I hope that I have been able to explain some of the possible relations between the institutional conditions of the university and the economic perspective planning of the society in general. Hopefully, these remarks will also help to put the content of this entire report into a wider context.

PART II

GENERAL INFORMATION AND OVERVIEW ON THE UNIVERSITY OF COPENHAGEN

Chapter 2

THE HIGHER EDUCATION IN DENMARK

by

Niels Hammer-Jespersen

Summary

In this chapter we give a short introduction to the concept of higher education and its principal features in Denmark.

The concept of higher education is very closely linked to scientific research, so that only education imparted on a scientific basis is classified as higher education.

In principle every person holding an examination from the secondary high school has a right of admission to higher education. At the same time a number of institutions of higher education have restrictions on admission. Therefore some institutions are able to restrict the new enrollment in accordance with the capacity, while others (especially the universities) are bound to accept every application. In a period of rapid growth in the number of students,this situation creates serious problems both for the "open door" institutions and for the politicians.

The concept

Higher education in Denmark can be distinguished from other kinds of post-secondary education by its inter-connection with scientific research. Only education imparted on a scientific basis and given at institutions that carry out scientific research is classified as higher education. The names of institutions classified as institutions of higher education are given in Table II. 2. 1. below.

Every person holding an examination (studentereksamen) from the secondary high school (gymnasium) has, in principle, the right of admission to the institutions of higher education. In some institutions a person can get the right of admission by passing a special entrance examination. A rather new kind of examination - an alternative to the examination from the secondary high school (højere forberedelseseksamen) - gives a limited right of admission. The idea is that a person can obtain admission to a certain number of studies, depending on the subjects he has chosen in his preparation for the examination.

Some features of the system of higher education

The Danish system of higher education is characterised by the principle of an open door policy. The only restriction is that one has to have an examination from the secondary high school (or the equivalent). However, at the same time, a great number of the institutions have restrictions on admission. Furthermore a number of institutions in other kinds of post-secondary education practice very severe restrictions on admission. This has the effect that a person who wishes to pass a post-secondary education, but has no intention of passing a higher education, can be forced into the higher education.

Another feature is that the studies at the universities are longer than those at other institutions. The result is that the number of students at the universities grows faster than at the other institutions, even if the increases in enrollment were the same. (See the following section.)

One of the major problems for the universities is that the increasing number of students causes an extension of the students' average length of study, which at the same time causes an additional increase in the number of students. The problem is that the quality of education may be lowered, as the number of students is increased, if the necessary steps to expand the universities are not taken at the same time.

At institutions with restrictions on admission the pressure from the students primarily expresses itself in the severity of the restrictions, but quality is not affected. If all the resources are used in expanding the universities, the effect will be that the capacity of other institutions can not be increased. In a period with an increasing number of applicants to higher education this will cause a gradually increasing pressure on the universities. As long as one has open-door universities and restrictions on admission to most other institutions, it is important to expand the latter so that their intake capacity can be increased.

In fact there have not been resources enough to expand all institutions quickly enough. Apart from a period in the late 1950's, resources have been so scarce - compared with the heavy demands - that the expansion of the institutions with restricted admission has been too small to keep pace with the increase in the number of applicants. The result has been an increasing pressure especially on the universities. This, of course, has resulted in a number of problems for the universities.

Further the Ministry of Education is not the only one concerned with education at the post-secondary level. A number of the post-secondary educational institutions with the most severe restrictions on admissions belong to other ministries. Therefore, the problem of coordination becomes important and it seems that this has not yet been solved in a satisfactory way.

Figures on higher education

In 1970 the total new enrollment in higher education was 4.6 times as large as just before the great expansion started in 1955. In the same period the number of students in higher education was increased by the factor 4.1.

Due to the expansion of non-university institutions of higher education in the late 1950's, the universities' share of total new enrollment decreased from 49% in 1955 to 45% in 1960, but then jumped up to 61% in 1965. The decrease in 1970, when the share of the universities was 56%, is due to a new admission policy of the Royal Academy of Fine Arts, which up to 1969 had placed restrictions on admission.

Because of differences in the duration of studies at universities compared with non-university institutions - the former being twice as long as the latter - the universities,share of the student population is greater than their share of new enrollment. The share was 53%, 50%, 66% and 67% in the years 1955, 60, 65 and 70 respectively

The pressure on higher education is only partly caused by demographic factors. In the period 1955-65 the number of 18 and 19 year olds increased by 44%, the frequency of passing the "studentereksamen" (the high school leaving exam) increased by 97% and the frequency of a student applying for a higher education increased by 21% (1). Although there has been a slow down in the increase of numbers in the relevant age groups, the two other factors - the high school pass-rate and the application rates - will probably still cause an increase in the number of applicants to higher education.

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(1) Niels Hammer-Jespersen, "Determinants in policy of higher education", Copenhagen 1969, unpublished.

Table II. 2. 1 - Institutions of higher education, number of students

Institutions	1955	1960	1965	1970
University of Copenhagen *	4959	6697	16862	23447
University of Aarhus *	1802	2406	5926	10773
University of Odense *	-	-	-	1193
Technical University of Denmark	1865	2110	2565	2879
Danish Academy of Engineering	-	387	921	1509
Dental College of Copenhagen	416	636	786	785
Dental College of Aarhus	-	303	397	465
Danish School of Pharmacy	268	614	675	587
Royal Veterinary & Agricultural College	878	937	1263	1473
Royal Academy of Fine Arts (1)	359	513	511	1424
School of Architecture in Aarhus	-	-	52	337
The Aarhus School of Economics and Business Administration (2)	241	435	746	1688
The Copenhagen School of Economics and Business Administration (2)	1619	2410	2859	4386
Academies of Music	426	450	457	468
Other	9	441	605	1458
Danish College of Education (3)	-	-	-	-
Universities *	6761	9103	22788	35413
Non-university institutions	6081	9236	11837	17459
Total	12842	18339	34625	52872

(1) Only School of Architecture

(2) Full-time students only

(3) Post-graduate education of teachers from teachers' training Colleges ; the number of students is not comparable to the other institutions.

Table II. 2. 2 - New enrollment in higher education

	1955	1960	1965	1970
Universities	1353	2158	5443	7158
Non-universities	1431	2601	3532	5701
Total	2784	4759	8975	12859

In 1955 the current expenditure to higher education was approximately 45 million Danish Crowns, in 1970 it rose to approximately 850 million Danish Crowns. In 1955 this expenditure amounted to 0. 16 % of gross national product, in 1960 to 0. 25 %, in 1965 to 0. 51 %, and in 1970 it was increased to approx. 0. 85 % of gross national product. This shows how fast the expansion in the sector of higher education has been. If we compare the increase in the share of gross national product used in higher education with the increase in the share of the population going to the higher education, it can be shown that from 1955 to 1970 there has been an increase in standards of approx. 30 %. This means that current expenditure per student in 1970 was 30 % higher than in 1955.

This underlines both the need for careful planning in the sector of higher education and for a careful administration of the resources allocated to higher education, in order to avoid waste in a period when there are political pressures to reduce the growth in public expenditure.

Chapter 3

THE UNIVERSITY OF COPENHAGEN ILLUSTRATIONS OF SOME PROBLEMS

by

Niels Hammer-Jespersen

Summary

In the first section the trend in the development of the University is discussed. It is shown that the overall student/teacher ratio is almost the same today as 15 years ago. It is also shown that the University today should be able to supply more teaching than before. However the teaching load today appears heavier than in the past due to a rapid increase in the students' demand for teaching and the use of new and more teacher-intensive educational methods. The major problem is that this development leaves teachers as well as students with a feeling of discontent, each group claiming more resources.

The new administrative structure of the University is discussed in the second section. It is argued that, in so far as the Konsistorium has up to now avoided assigning any priorities among subunits, it is difficult to see how the new structure itself would make any difference.

Thirdly, the budget procedure is discussed on basis of analysis of the budgets of the Social Science and the Natural Science Faculties. The main conclusion is that the Faculties in one sense behave more flexibly than the Konsistorium. It is shown that the Natural Science Faculty allocates the non-tenure teachers according to developments in the teaching load.

In the Social Science Faculty the main priority is probably given to research where permanent appointments are concerned. In the Natural Science Faculty the permanent appointments were allocated in accordance with a modus vivendi stating that the distribution of tenures among Institutes should be almost constant. Finally the conclusion in this section is that the Faculty suffers from the same weakness as the Konsistorium, that of being too broadly composed and not able to formulate common objectives.

As regards the information from the Budget Office and the Bookkeepers Office it is obvious that there has not been any demand for organizing the possible information in such a way that it could be used in budget evaluation or the evaluation of economic behavior.

The large data-files are organized in the academic administration. Recently some major improvements have been initiated which should allow the Budget Office to make better budget proposals, in the sense that it can present to the Konsistorium a set of alternative proposals and show their consequences.

In the concluding section it is argued that good plans can only be set up with cooperation between decision-makers and planners. If the decision-makers are unwilling to explain themselves, then the planners can present them with a set of alternative plans and either get acceptance for one of the plans or be ordered to set up a new plan or another set of plans according to defined objectives.

Introduction

The University of Copenhagen has an open door admission policy.

When the great expansion in applications for higher education started in the late 1950's the University had to accept a very rapid increase in new enrolment. Consequently the number of enrolled students also increased rapidly. This was primarily caused by the fact that traditionally studies at the University have a duration of 5 to 7 years, which causes a rather long lifespan for the student population, and for drop-outs as well. Further more, it has been seen that students waiting for vacant seats in institutions with restricted admission "wintered" or hibernated at the University.

In the previous chapter it was mentioned that in the late 1950's resources were fairly abundant and a number of investments in new buildings were started. However, the majority of the investments were made in the field of technical and natural science education, while the students began in about 1960 to turn their interest towards the Social Sciences and the Humanities.

The purpose of this chapter is to illustrate and discuss the problems arising from this trend of development.

Main features of the development trend of the University of Copenhagen

In 1955 the University of Copenhagen accounted for 39 % of all students enrolled in higher education. In 1960 this share had fallen to 37 %, but in 1965 it rose to 49 %. As mentioned in Chapter 1 this was clearly caused by the great expansion in the number of applicants, combined with restrictions on admission to a number of other institutions. In 1970 the share had fallen to 44 %, partly due to the opening up of the School of Architecture at the Royal Academy of Fine Arts and partly to the establishment of the third university in Odense.

The figures show that the problems of the University must be regarded as major problems of the system of higher education as a whole. The ways in which they can be solved are bound to affect the rest of the system. However the purpose of this project is not to solve the larger problems. The purpose is only to create some tools, which at first can be used to facilitate the administration of this great unit, and if they prove workable, can be used in the planning processes for all higher education. It is therefore necessary to identify the problems.

In the two following tables the new enrolment and the total number of enrolled students are shown together with their distribution on the five faculties and the group "study not selected".

From Table II. 3. 1 it can be calculated that the Faculty of Philosophy has had the greatest increase in new enrolment,and it has doubled its share of the enrolment from 21 % in 1955 to 42 % in 1970. The share of the Social Science Faculty is almost constant around 17-18 % (except for 1965 with 22 %). The share of the Natural Science Faculty increased from 8 % in 1955 to 16 % in 1960 and thereafter it has remained almost constant. Furthermore , the Faculty of Medicine and the group "study not selected" have lost ground. Their respective shares were 22 % and 28 % in 1955 decreasing to 14 % and 10 % in 1970.

Table II. 3. 1 - New enrolment, University of Copenhagen

Faculty	1955	1960	1965	1970
Philosophy	221 1)	411	1394	1838
Medicine	233 1)	320	613	598
Social Science	181 1)	276	835	793
Theology	35 1)	34	79	45
Natural Science	82 1)	255	509	665
Study not selected	294 1)	328	440	444
Total university	1046	1624	3874	4372

1) Estimates.
Source : Statistics from the Ministry of Education.

The next table, II. 3. 2, shows similar trends in changing distribution of the number of students, but as the absolute figures are greater the fluctuations in the shares are smaller - but the tendency is clear enough.

Table II. 3. 2 - Number of students per Faculty, University of Copenhagen

Faculty	1955	1960	1965	1970
Philosophy	1297	1853	6158	9976
Medicine	1532	1832	3542	4220
Social Science	1139	1451	3789	4821
Theology	257	253	394	418
Natural Science	407	915	2366	3395
Study not selected	327	393	611	617
Total university	4959	6697	16860	23447

Source : Statistics from the Ministry of Education.

If we compare the number of teachers with the number of students enrolled, we can get an estimate of how standards have developed. Unfortunately, only for the recent years has it been possible to get information on the distribution of the teachers by faculties. Further more, the development of regular statistics on teachers is only in its early stage. (Such statistics were established to cope with new income-tax regulations and also because a new electoral system for representative positions at the university was introduced.)

However, by looking at the budget (Finansloven), it is possible to see which and how many positions have been accepted by the Parliament (Folketinget), (see Table II. 3. 3). First of all it is remarkable that the number of students per full time teacher is almost the same in 1970 as it was in 1955. Also the standards as measured by the number of students per full time teacher declined between 1960 and 1965, but increased by 1970. In the study by Niels Hammer-Jespersen mentioned earlier it was shown that the standard, measured here as operating costs per student at constant prices, declined from 1962 to 1965 but in 1966 it increased again. These observations fit well with what is shown here. The heavy increase in the number of students took place in the period 1960-65 and in that period it was difficult to expand the university fast enough to keep the standards unchanged. It is however important to notice that ~~in the~~ period 1955-59 the annual number of graduates from the universities was on average 620, in the period 1960-64 it increased to only 690,which is by 11 %, while the number of students increased by 152 %. Therefore it was not possible to recruit a sufficient number of teachers in order to keep the standard unchanged. In the following period (1965-69) the number of students increased by 40 %, but the number of graduates by approximately 80 %. This explains why it was possible in 1970 to reestablish the student/teacher ratio prevailing in the period 1955-1960.

Table II. 3. 3 - Number of positions (tenures) at the University of Copenhagen, 1955, '60, '65 and '70

	1955	1960	1965	1970
Professors	128	154	183	232
Associate professors	5	51	72	142
Assistant professors	155	183	484	962
Total full time teachers	288	388	739	1336
Non-teachers	224	271	806	1247
Total number of tenures	512	659	1545	2583
Students per full time teacher	17, 2	17, 3	22, 8	17, 6

Sources : Budget proposals for 1955-56, 1956-57, 1960-61, 1961-62, 1965-66, 1966-67, 1970-71, 1971-72.

From the annual budgets it can be calculated that running costs,apart from wages,and measured in constant prices,have been almost constant per full time teacher since 1960. In 1955 the running costs per full time teacher were 22. 500 Danish Crowns (D. kr.), in 1960 and 1965 27. 500 D. kr. and in 1970 28. 000 D. kr. (1955-value).

In the budget the share of the wages has increased from approx. 60 % in 1955 and 1960 to 65 % in 1965 and to 70 % in 1970. This is due first to the fact that wages have increased faster than the prices, second to the increasing number of non-teachers (technical assistants etc.), and third to the increase in the number of part time teachers. Regarding the second reason,it can be mentioned that the ratio of non-teachers to teachers has increased from approx. 0, 80 in 1955 to 0.95 in 1970 (but it was 1.10 in 1965). As for the third reason, it is almost impossible to give exact figures for the development in the number of part-time teachers due to the weakness of the statistics on teachers.

The first conclusion of this section is that students should be better off today than at any other time in the past 15 years. First of all the fact that the number of students per full time teacher was almost the same in 1970 as in 1955 should be compared with the development in the students distribution among Faculties. The movement here has been towards the Humanities which by tradition is less resource-consuming than Medicine and Natural Sciences, which have declined in importance. This means that if standards for the individual Faculties have remained unchanged from 1955 to 1970, then the average (and that is what is shown here) would have shown a greater number of students per full time teacher than it actually does. Furthermore, there has been a rapid increase in the number of part time teachers, and that increase has certainly been greater than the increase in the number of students.

The next conclusion could be that teachers too should be better off. There is almost the same number of students per full time teacher as 15 years ago. Each teacher has the same amount of money available as 10 years ago and approx. 20 % more than 15 years ago. This money covers all other costs than wages and is used for teaching, research and administrative purposes. Furthermore, each teacher today is served by more technical assistants than in 1955. He can also supply more teaching due to the expansion in the number of part time teachers.

The first modification to these rather optimistic conclusions is that both of them state that the student or teacher should be better off. Not that they are better off. This is because it is impossible to trace the trends of individual Faculties. The conclusion is therefore that the resources available for the University have been abundant enough to insure that all Faculties and their teachers as well as their students could have been better off today than 15 years ago. But since information on the distribution of resources to the Faculties was not available it is difficult to draw the above conclusion.

By talking to people at the University one can easily get the impression that everyone is worse off. However, this cannot be true according to the above mentioned trend of overall development. The first thing that can give people the feeling that things are worse is the obvious skewed distribution of physical facilities, which has favoured primarily the Faculties of Medicine and Natural Science. The other Faculties are still situated in the City of Copenhagen, partly in the old University-buildings and partly in old houses bought or rented and sometimes even in rented single rooms. In itself this development is not satisfactory, and it becomes even more unsatisfactory since the major increase in the number of students has actually taken place in the Faculty of Philosophy.

The problems arising from this development are partly outside the scope of this part of the study. However, they need to be mentioned because they give an indication of the fact that the Medicine and Natural Science Faculties have not only gained by getting better physical facilities ; but by getting more and better equipped rooms they have possibly been able to get a bigger share of the resources than they really needed, when compared with the development in the number of students in the two faculties.

A second important feature in development over the past 15 years is the great increase in demand for teaching activities. In the beginning of the period almost all teaching was conducted as lectures. They still play a role today, but only as a part of a broad spectrum of exercises, seminars etc. All these activities usually demand small class sizes and therefore call for a lower student teacher ratio. Since this ratio has been kept constant (overall) and since the development in the distribution of teachers has probably favoured the Medicine and Natural Science Faculties, it is obvious that the teaching load today is heavier than before.

The major problem can then be isolated as follows. The number of full time teachers has increased at the same rate as the number of students and the number of part time teachers even more. The evolution of the distribution of students has led to an increased overall standard. By taking these two things together it follows that there has been an increase in the supply of teaching activities. But, on the other hand, the demand for teaching has obviously grown faster than the supply, so that the teaching load appears heavier today than before, which leads to a demand for more resources.

The question is then : How has it been possible for the University to get into this situation of increasing standards and at the same time a widespread feeling of discontent and claims for more resources ? In the following section we will try to answer the question by looking at the administrative structure of the University, the budgetary processes and the information system.

The administrative structure

Unfortunately it is not possible today to give a precise description of the administrative structure of the University since at the moment it is in a process of change. However, it is possible to give an outline of the new structure.

In the old administrative structure there was a definitive distinction between the academic and the economic (or business) administrations. The academic administration was organised inside the University, while the economic administration was organised in an independent body outside the University. In itself such an arrangement could give rise to conflicts, especially when it is noticed that the academic administration (personified in the Konsistorium) alone was competent to decide on the budget, but not responsible for the economic dispositions. That responsibility was placed in the economic administration, which on the other hand was not permitted to decide on the budget.

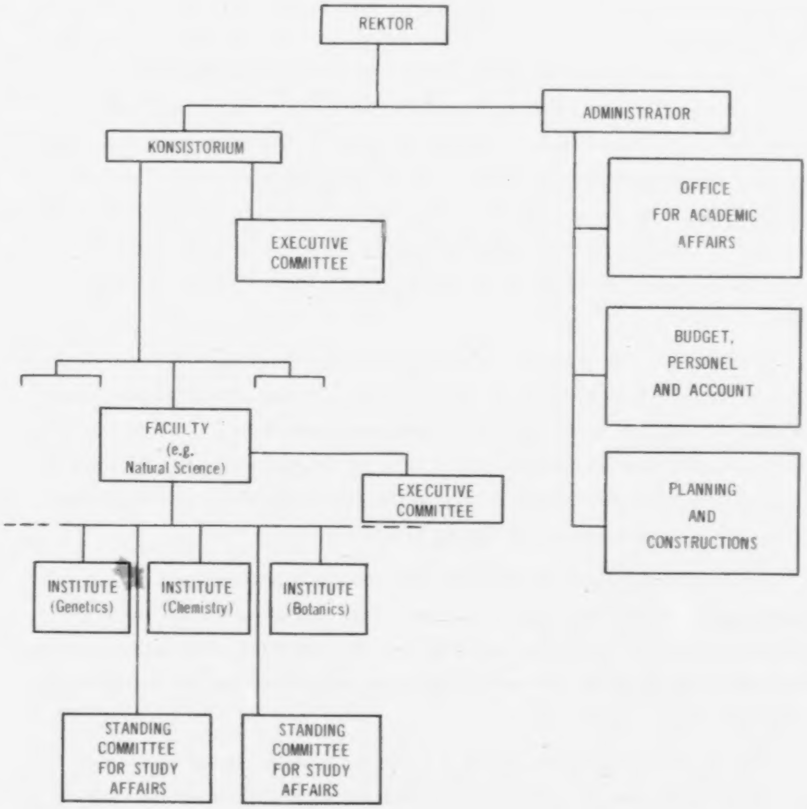
In proposing a new structure, a main point of view was that the best possible utilization of the resources should be secured. One way of doing this was to set up the administration so that it could make fast and determined decisions. Therefore it was decided to cancel the independent economic administration and set up a single administration, and to make the Rektor the Head of the University. The Rektor should be assisted by an administrator, but the Rektor should be the superior. In this way competence and responsibility would be linked. However, this reform would only serve parts of the problems of the University. If the result of the reform is shorter and more direct ways of communication, then many problems arising from a time consuming treatment of issues could be avoided, at least by letting the issues pass on to the responsible and competent body faster than today.

However, a new structure alone does not secure "better" decisions, but there are some indications that it could be the case. The shorter means of communication causes an earlier involvement in the issues by the competent body. This could mean that the body would be more motivated in treating the matter. Further it is possible that the shorter means of communication would secure a better and more reliable set of information (data), which could make it possible for the bodies to make decisions with less uncertainty than today. The main questions however will certainly continue to be : How do the different bodies act? And which interests are involved ?

As regards the last question the new structure involves an increasing participation of students in the decision processes of the University. Unfortunately, there is up till now no experience of the kind of interests the students represent. It is therefore not possible to make any statement on the question of whether student participation means that the bodies will act in a way different from before.

Figure II.3.4.

FROPOSED ADMINISTRATIVE STRUCTURE
OF THE UNIVERSITY OF COPENHAGEN


REKTOR
KONSISTORIUM
ADMINISTRATOR
EXECUTIVE COMMITTEE
OFFICE FOR ACADEMIC AFFAIRS
BUDGET, PERSONEL AND ACCOUNT
FACULTY (e.g. Natural Science)
EXECUTIVE COMMITTEE
PLANNING AND CONSTRUCTIONS
INSTITUTE (Genetics)
INSTITUTE (Chemistry)
INSTITUTE (Botanics)
STANDING COMMITTEE FOR STUDY AFFAIRS
STANDING COMMITTEE FOR STUDY AFFAIRS

In relation to the question asked in the former section it can be said that in the old as well as in the new structure the Konsistorium is the ultimate competent body.

Since the financial year 1966-67 the overall budgeting system in Denmark has been a system with ceilings on expenditure (for a description and discussion see Part III). As a consequence the University of Copenhagen has been given its own ceilings, within which it can make its own proposal concerning the budget. This ceiling is given by the Ministry of Education to the University as a lump sum,and the University is then supposed to decide on the internal distribution among faculties and common activities.

The problem which was discussed in the former section arises from the fact that the Konsistorium does not distribute the total available budget to the subunits of the University. This means that when the Konsistorium receives the budget-ceiling for the University it does not go into a discussion on priorities between the activities of the different subunits. The reason for this could be that the Konsistorium wants more information before it can make decisions. The Konsistorium therefore calls for budget proposals from subunits. However it does not call for total proposals but only for marginal proposals. The first consequence of this is that resources once allocated to a subunit will remain there and will be withdrawn from any future considerations in the budget. The Konsistorium therefore gives up the disposal of over approximately 90-95% of the budget.

The second consequence is that the proposals from the subunits are made without consideration of the limits given by the ceilings. When the proposals from the subunits are received by the Konsistorium,one would think that it now would have obtained the desired information on the basis of which to make its decisions. But the case seems to be that the Konsistorium at this stage also avoids any decision-making and setting priorities.

Until now all proposals were cut proportionally so that the University's budget would conform to the given ceiling. This way of allocation can not be called real decision-making:it punishes the one who tries to calculate realistic needs and it rewards the one who can propose extensive, but not necessarily realistic, needs.

The allocation therefore is not a result of serious consideration of the real needs of the subunits in relation to education as well as to research. It is a result of what demands the subunits can create when the proposals are made. The problems of the University are then a consequence of the fact that until now the Konsistorium has avoided assigning any priorities among subunits. This leaves the Faculties and other subunits in a state of dissatisfaction, which is probably because the actual allocation is not a result of any explicit objectives or overall policy.

The budget procedures at the Faculty level

The budgetary-system at the University is part of the ordinary four-year public budgeting-system. For the first of the four years an ordinary budget is made, for the following three years budget-estimates are made, (see Figure II.3.5). In this way the different decision-making units are able to plan with knowledge not only of the resources available in the first year but also on the following three years. However, the Institutes and the Faculties do not look at the budget estimates as particularly binding, one of the reasons being that they do not want to be tied down too much to the estimates. Apparently the estimates are not done with great care. The available data show that Institutes and Faculties each year calculate their needs without attention to the ceiling of the budget for the second year, which was fixed in the previous year.

As mentioned in the last section the budget procedure at the Faculty-level (and below) only deals with the margins, taking already allocated resources for granted. This means that the proposal for the budget (year 1) is calculated as last years budget (for the Faculty or Institute) plus a margin. However what is worse is that the proposal for the first estimate (year 2) is calculated as the budget two years earlier, plus the margin for year 1,plus another margin for year 2. This way of calculating pays no attention to the risk that not all of the margin for year 1 maybe accepted, which can easily be the case, as the Konsistorium has to keep the sum of the marginal proposals from all Faculties within the limits of the ceiling given by the Ministry of Education.

When we look at the running costs we see that only two kinds of resources are used (1) money and (2) manpower. Usually we have to look at the physical facilities as resources as well, but they are not viewed by the budget as a scarce resource. This can be explained by the fact that all problems of accomodation are administrated by a central office at the University. For this reason the Faculties do not have to pay rent and maintenance costs. The amount of money necessary for this purpose is taken beforehand from the allocated ceiling.

Manpower is separated as a special type of resource not because there could be a greater scarcity for certain types of manpower, but it is argued that the Wage Board (Lønningsradet) demands a reasonable request for each individual new position which is proposed. If a proposed position is turned down by the Wage Board, then the University looses the position as well as the amount of money allocated for salary (See Part III, Chapter 5).

Within the scope of the project special investigations of the budget procedures have been carried out at the Social Science and the Natural Science Faculties. The Social Science Faculty is located in the "old" University in the city of Gopenhagen, while the Natural Science Faculty is located in quite new buildings in the Nørre Fælled-area. This fact creates differences between the two Faculties. Furthermore the Social Science Faculty is less manpower-consuming and uses less floor space per student or per teacher than the Natural Science Faculty. In 1970 there were approximately 4800 students enrolled in the Social Science Faculty and approximately 3400 in the Natural Science Faculty.

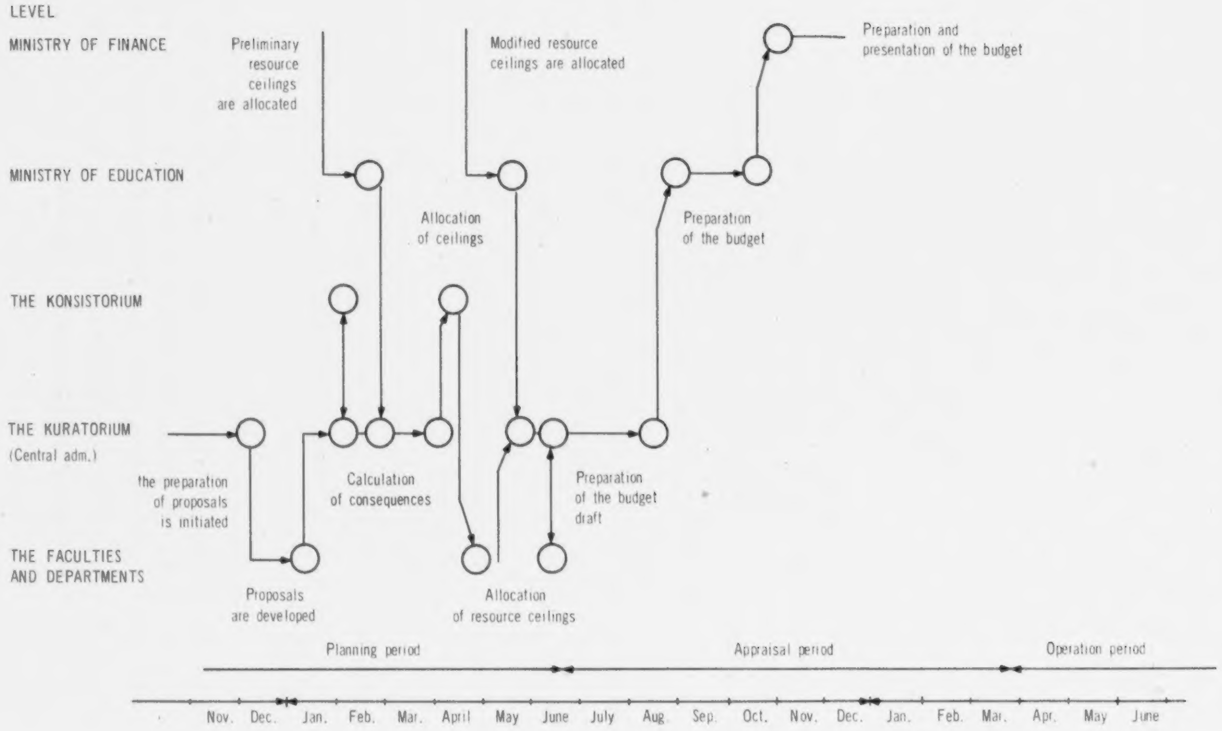
At the same time there were 56 teachers (tenures) in the Social Sciences and 492 in the Natural Sciences. In the Konsistorium the two Faculties each have four members, the total number being 21. (This will, however, be changed according to the new law on the government of the universities).

It was a general feature for the two Faculties that their wishes for budget additions were concentrated in the first year, while they diminished in the following three years. In the second year the same proposal appeared, what had been rejected in the first year was then added to the second years'' proposal.

Unfortunately, the budget materials for the Social Science Faculty were very poor, especially as the totals for many items in the last years' budget were lacking. In this way it was not even possible to add the desired marginal increases to a base to get an idea of the total resources allocated to the Faculty. This was especially the case for the non-tenure teachers, who play an important role in the Social Science Faculty. However, one thing turned out to be reasonably clear : the Faculty wants a relative increase in the number of assistant professors (the Danish term can be translated as "scientific assistants"). In 1968 there were approx. 190 students per professor and in 1974 it is estimated there will be approx. 200 students per professor. For the assistant professors the corresponding figures were approximately 300 in 1968 and are estimated to be approximately 160 in 1974. At once this looks as if the Faculty gives a high

Figure II.3.5

DIAGRAM OF THE BUDGETING PROCEDURE


LEVEL
MINISTRY OF FINANCE
MINISTRY OF EDUCATION
THE KONSISTORIUM
THE KURATORIUM
(Central adm.)
THE FACULTIES AND DEPARTMENTS
Preliminary resource ceilings are allocated
Modified resource ceilings are allocated
Preparation and presentation of the budget
Allocation of ceilings
Preparation of the budget
the preparation of proposals is initiated
Calculation of consequences
Preparation of the budget draft
Proposals are developed
Allocation of resource ceilings
Planning period
Appraisal period
Operation period
Nov.
Dec.
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June

priority to its educational purposes, as the teaching capacity of the Faculty has increased. A professor is normally expected to give 2-4 lessons per week and assistant professors 6-8 lessons per week. However the conclusion must be rejected. A look at the official lecture list shows that in the Social Science Faculty no assistant professor gives any lessons unless he is a lecturer too, which gives him an additional payment of approximately 25. 000 D. kr., and even then he offers only 2-4 lessons per week. This indicates that priority is primarily given to research and this conclusion is confirmed by the observation that today (May 1971) approximately one third of the assistant professors hold a doctors degree. (In the Natural Science Faculty this is the case for approximately one seventh of the assistant professors.)

Another important observation is that it is only very recently that the Faculty requests a constant running cost (annum) per scientific position. In the early years of investigation it was found that the running cost per position was apparently calculated as a residual which fluctuated considerably.

The analysis gives two main impressions of budget making in the Social Science Faculty. They, first is that the Faculty has not taken advantage of the time-aspect in the planning (the four-year budgets). Secondly, the Faculty, as far as the permanent positions are concerned, has given priority to research, and this conclusion is based on the fact that assistant professors give lessons only if they are lecturers at the same time. However this is not mentioned in budgets,where the arguments are based on the number of students and no research policy is formulated.

As far as the Natural Science Faculty is concerned the first observation is that here too the needs exceed the resources allocated.

The investigation of the Natural Science Faculty was carried out in two phases,(1) at the Faculty level and (2) at the Institute level.

At the Faculty level it was seen that a manpower unit was used which consisted of 1 professor, 5. 5 assistant professors and 2. 6 lecturers. The number of associate professors per professor has been slightly increasing while the number of technical assistants per teacher position has been decreasing. The running costs per teacher position have been increasing over time. However it is difficult to reach definite conclusions when we look only at the Faculty as a whole.

At the Institute level, each new professor was provided with the same number of assistant professors as old professors had been,but the lecturers were allocated in a more flexible way. This was so because the new professors - and consequently the new assistant professors too - were allocated in a way that the relative distribution of professors among Institutes was more or less constant.

However, the distribution of students among the different Institutes was not constant, because during the period investigated there has been a movement of students from Mathematics, Physics and Chemistry to Biology, Geography, Zoology and Botany. Consequently the teaching load on the Institutes changed over time, as long as the distribution of permanent teacher-position was constant. This was then compensated by the distribution of the new lecturers.

Another way of compensating for the consequences of the distribution of permanent teacher-positions was by the allocation of the marginal additions to running costs. It was observed that the margins were primarily allocated to the Institutes with an increasing teaching load. The running costs are decided for the research as well as for the educational activities. The starting point - when running costs are going to be increased - could be the objective that for each permanent teacher position there should be a proportionate allocation of research, this research having the same cost for both new and old positions. One would,therefore,ask for increases in the running costs when the number of positions and/or the teaching load increases. As the existing budget procedure only demands proposals for marginal additions and not for total budgets, it has in it a built-in tendency to ever increasing running costs. If the teaching load is constant or decreasing,one would ask for a zero-addition. With decreasing teaching load per position, and within a given sum of running costs, a greater proportion of resources could be used for research purposes. And this greater "research-running cost" would be the basis for calculation if teachers were to expand at the institution later.

As far as technical assistants are concerned the investigations at the Faculty level left us with the question of the lowered ratio of technical assistants to permanent teachers. The result of a more detailed investigation on the Institute level showed an almost constant ratio, so the conclusion if anything should be that the result on the Faculty level was caused by the fact that both teacher and technical assistants by definition have to be integers, and that new professors are provided with the same technical assistance as the old professors.

The main conclusion as far as the Natural Science Faculty is concerned is then that the allocation between Institutes of the resources allocated to the Faculty, to a certain degree, seems to be more flexible than the Konsistorium's allocation between the Faculties of the University. However this should not be surprising as the Faculty is supposed to have more in common with its subunits than the Konsistorium. However what is surprising is that the Faculty appears only to be concerned with the marginal additions to its budget. This will work as long as the margins are large enough, but it is obvious that there will be trouble even at the Faculty level if the expansion of its budget stops.

Table II. 3. 6 - Selected characteristics of the Natural Science Faculty 1968/69 and 1970/71

		Mathematics	Chemistry	Physics	Biology	Zoology	Zoophysiology	Botany	Geology	Geography	Gymnastics	Arctic Station	Total
Percentage of professors	68/69	17	3	27	10	10	3	7	8	7	3	0	100
	70/71	19	7	27	10	8	4	6	9	7	3	0	100
Ratio of Prof. /assist. prof.	68/69	0.53	0.11	0.24	0.23	0.12	0.20	0.11	0.16	0.26	0.67	0	0.20
	70/71	0.50	0.10	0.25	0.23	0.11	0.25	0.10	0.17	0.24	0.67	0	0.20
Ratio of Lect/prof.	68/69	2.1	6.8	1.5	2.0	2.8	1.0	2.5	3.0	3.3	4.0	-	2.6
	70/71	1.8	7.0	1.5	2.3	3.5	1.0	2.8	2.8	3.0	4.5	-	2.6
Ratio of Tech. ass./ Teach.	68/69	0.2	1.0	1.1	1.0	1.3	1.5	1.5	0.8	0.5	1.3	1.0	1.1
	70/71	0.2	1.0	1.1	1.0	1.4	1.4	1.4	0.9	0.5	1.3	1.0	1.1
Running costs (1) per teacher	68/69	10	24	33	23	13	21	15	15	9	16	45	21
	70/71	10	29	36	27	16	33	16	17	9	20	51	24

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(1) 1000 D. kr.

When we compare the Faculty-level and the Institute level we notice some rather impressive differences in behavior. For the Faculty as a whole the behavior seems much more inflexible than when it is divided into Institutes. But why is it not more flexible ? Why are the teachers with permanent appointments distributed to Institutes in such a way that each group of Institutes over time has almost the same share of the teachers (tenures) ? The explanation could be that the Faculty attaches major importance to the research content in the scientific appointment. However there is no evidence indicating that within such a broad area as the Natural Sciences, each discipline should have the same rate of growth in a scientific sense.

A reasonable explanation of the mechanical budgeting of scientific appointments could be the organizational structure of the Faculty. Compared with the Konsistorium the Faculty appears more as a unit, but this cannot hide the fact that the Faculty is composed of a number of very different Institutes, each cultivating its own discipline. The Faculty must make a budget proposal common for all its Institutes, but there is no guarantee that the different Institutes have a common interest. A way out of this difficulty is a system where no single Institute or any group of Institutes can dominate and get a lion's share. A system of this kind could probably be one where some key items in the budget (e.g. the number of professors) are kept in balance between the different Institutes or groups of Institutes. If it was an unwritten rule that each new professor should have the same number of assistants as the old professors, then the number of assistant professors could be calculated directly on basis of the number of professors. However such a modus vivendi pays no attention to the development in the distribution of the students, and therefore the Faculty needs some resources which could be allocated a little more flexibly. The lectureships (non-tenures) and the running costs are obviously used for this purpose.

A narrower professional demarcation of the budgeting units would presumably result in a more flexible allocation of the total resources even if there were no change in the Konsistorium allocation. The primary consequence would be that the budgeting units when making their budgets do not have to pay attention to the balance between them. Furthermore, it would be easier for the central authorities to evaluate the wishes of the different units and apply the considerations which the educational policy requires.

The conclusion of this section is almost the same as that of the previous section. The Faculty is obviously too broadly composed and therefore not able to formulate a common objective, except the desire to have the largest possible budget allocation.

The budgeting and accounting systems as sources of information

When the analysis of the budget of the University and the sub-budgets for two specific Faculties was made, it soon became clear that one of the reasons for the uncertainty in the budget-making was the insufficient data on students and teachers as well as on the costs of the different activities. As mentioned above this uncertainty resulted in a procedure where a year's budget consists of two parts, first the last year's budget and then a marginal addition for the new year. Obviously, no evaluation of the old budget takes place, it just runs on from one year to the next. However such an evaluation cannot be done without precise information on what is going on at the University. This information is a combination of a certain number of primary data on the number of students, teachers and information on the prices of different kinds of resources including teachers.

It is clear that in the Budget Office a lot of data is collected on the allocation of the last and the next to the last years' budgets. For each Institute the Office has information on the number of positions such as professor, associate professor, assistant professor, lecturer, technical assistant, teaching assistant (non-tenure) and other different kinds of positions. Furthermore the amount of money for allocation to meet the running costs and travelling, larger apparatus and ad hoc assistants' costs is known. It is however important to note that the Budget Office has no information on the activities on which the allocated resources are actually used. The Budget Office is therefore not able to evaluate the use of the present budget and to propose reallocations of already allocated resources or to set up alternative budget-proposals.

Also in the Bookkeepers Office a lot of data is collected. However the accounting system of the University is primarily oriented towards the public accounts and the rules set up for this purpose.

The accounting system should however serve other purposes than just collecting data on amounts of money paid. For the University this purpose could be a kind of budget-control, so it would be possible to see what was used for different kinds of activities and in this way make a budget evaluation possible.

The bookkeeping function at the University is very centralized and only a few Institutes keep their own books. This has two important effects :

First, for all Institutes with centralized bookkeeping it is only possible to see to whom money is paid, but not for what purpose (teaching or research). Further, from an analysis of the Institutes in the Natural Science Faculty it became clear that there is a tendency to uneconomic behavior : for a large number of Institutes the major part of the payments were effectuated in the last two months of the financial year. Moreover all Institutes acted completely independently in buying and stock-keeping.

Secondly, for the Institutes with individual bookkeeping the only thing reported to the Bookkeeper's office is a monthly total of payments (distributed on the relevant budget-accounts). In this case it was not possible to see to whom the money was paid. These Institutes with individual bookkeepers have a more regular payment behavior.

In connection with the question discussed here it can be said that the accounting system is a consequence of the budget-accounts. And - as it will be discussed further in Part III - the budget-accounts are not usable for analytical purposes. It is therefore not surprising that the accounting system too cannot be used for analytical purposes.

However, although the accounting system is legally connected with budget-accounts it could be organized in such a way that it could answer the questions which should be asked before the budgets are made. The reason that it is not able to answer these questions can only be that it has never been demanded to do so.

Quite another thing is that the accounting system, as it is, shows a characteristic behavior on payments (a majority of all payments are effectuated in the last two months of the financial year) and that the Institutes are too independent in buying and stockkeeping. It is quite certain that great savings could be achieved by a certain centralization of stockkeeping. However, for the individual Institute, considerations of this kind are not just around. First of all it seems that they do not feel the need for cooperation with other Institutes and secondly there is no economic incentive to such a cooperation : interest is not paid on money which is tied up in stocks.

The conclusion of this section is that there obviously never has been any demand for organizing the information from the Budget Office and the Bookkeepers Office in such a way that it could be used to evaluate the utilization of allocated resources as well as the economic behavior of the individual Institutes.

In the discussion on the University structure it has been proposed to set up a Planning Group that should set up plans for the future. Such a Planning Group needs close cooperation with the Konsistorium's Budget Committee. Based on what has been found out here we will propose that the two Groups should have common secretarial assistance, in order to make sure the future budget-proposals are set up in light of the long run plans and that the plans are feasible in light of what is realised in the short run.

Furthermore we will propose that the individual Faculties and groups of Institutes develop more competent administrative capacity. This should be done partly in order to get reasonably uniform administrative behavior through out the University and partly to strengthen the administration compared with the academic sector and its sometimes condescending attitude towards administrative work.

The data-files as sources of information

The great data-files of the University are administered by Data- and Service Office. In this section we will give brief comments on the existing files and we will try to evaluate the plans of the Office for combinations of the different files and their usefulness.

One major file is the Student-matrikel, which contains a complete register of all enrolled students with names, addresses, CPR-number, (code in the Central Person-Register), year of matriculation and name of the study to which the student has enrolled. On the basis of this information a number of tables can be set up, which unfortunately cannot be used in planning and budgeting.

Tables are set up with distribution on sex, age, study, and matriculation year. The last distribution enables one to see how many of any matriculation-cohort are left in the system. But it is not possible to see how many of the enrolled students are active or passive and it is not possible to see on which level of the study the students are. This last item is very crucial in the sense that the study-plans operate with different levels, each with different demands for resources. However, as long as nobody knows anything on the transition coefficients it is almost impossible to make plans for more than one year ahead. It is therefore not surprising that the budget-estimates - as mentioned earlier - have been very poor. The student-file has up to now not been able to supply the decision-makers of the budget with any information on how the student population was expected to be distributed among the different levels and different activities with their varying demands on resources.

Another major file is the Stabs-matrikel, which contains a complete register of all teachers and other employees. All information in this file is controlled by the CPR-number.

As far as the teachers are concerned the Stabs-matrikel should make it possible to calculate the teaching capacity at the University totally as well as partially. The partial teaching-capacity should also be calculated for Faculties or subunits of Faculties and for different kinds of teachers.

Furthermore it is intended that the Stabs-matrikel shall contain information on wages and salaries. This will make it possible to carry out relevant calculations of the wage-cost and its distribution on different Faculties, students etc. (Wages and salaries cover approximately 70 % of the total costs.)

Finally the Stabs-matrikel will contain information on dates of appointment, dismissal and promotion. When this is established it will be possible to calculate a mortality table, which is very important when the University formulates a manpower policy.

The Data- and Service Office has started creation of an Examinations and Teachings Administration. When it has been created it will contain a lot of very important information, which can be used in future budget-making procedures. The administration will contain knowledge of each teaching activity, who the teacher is, and how many students are engaged in the particular activity. Also the different activities will be linked together to the extent that participation in one activity presumes the passing of other activities.

When this administration is established there will at least exist the possibility of making a statistic on "study-progress", whereby it should be possible to predict the distribution of the students on Faculties and subunits of Faculties as well as on levels of study in the Faculties and subunits.

The applicability of an information system cannot be evaluated in terms of the quantity of data made available. The system must be organized in such a way that it can procure (1) relevant information by a certain date (the budgeting procedure is a yearly returning event) and (2) data on short notice for non-foreseen decision-situations.

Looked at from this point of view we cannot say that the existing information system at the University is appropriate. But the establishment of the Stabs-matrikel and the Examinations and Teachings Administration will undoubtly improve this situation to a great extent. Add to this the putting together of the formerly independent economic and academic administrations, which we can hope will make it easier for the administration to present relevant information when the Konsistorium decides on the budget and its internal allocation.

In Part IV we will return to the question of relevant information and try to explain more precisely what we understand by this term. Here we shall repeat briefly what is said in this and the former section.

In two or three years the University of Copenhagen will have statistics on "study-progress" available. From these statistics and the Students-matrikel it should be possible to estimate the transition-coefficients of the system. In the Examinations and Teachings Administration we can see which specific activities a given study involves, and this taken together with the knowledge of the transitions - coefficients will make it possible to estimate the teaching load on the tenures and the need for non-tenures. Given this it is possible to estimate the total salary cost for given coefficients. In the Bookkeepers Office there will be knowledge available on the cost-structure and it will therefore be possible to estimate the total costs when the wages and salaries are given.

However, it does seem strange that the Konsistorium, up to now, has not demanded a satisfactory basis for the decision-making on the budgets. The reason could be that the administration has not been able to supply this information. There is a certain degree of truth in this, recalling that it was only the implementation of the pay-as-you-earn tax-system and the new electoral rules for the different University-bodies that forced the University to build up a data-file on all employed persons.

Now the question is whether the Konsistorium on the centralized level and the individual budget-committees on the decentralized level will take advantage of the improvement of the total information system, which will take place in the coming years.

To answer this question we must take a look at the techniques which are used in the administration. It is only in the Data and Service Office that EDP is used, which however is a necessary precondition for handling the great data-files, with approximately 25,000 students in the Students-matrikel and approximately 10,000 employees in the Stabs-matrikel (tenure, non-tenures, technical assistants and all kinds of hourly paid assistants). In the Bookkeepers Office a mechanical bookkeeping system is used, while the Budget Office prepares everything by hand.

It is the Budget-Office that shall order the collection of information either directly or from the Data-and Service Office or the academic administration, and it will be the Budget-Office that shall prepare the information in order to provide an adequate basis for the decision-making in the Konsistorium. This work cannot be done without assistance from EDP. Therefore the Budget-Office has to be strengthened so that it can both formulate the problems (for a given objective), call for relevant information and prepare it using the EDP-technique.

However, this is only one side of the problem. The other - and presumably the decisive one - is whether the Konsistorium is able to formulate a common policy for the total University.

Conclusion

The University of Copenhagen will now face a period with very serious restrictions on the growth rate. It is therefore necessary that the University in the future carefully determines priorities when it allocates new resources and that it makes already allocated resources the object for critical reconsiderations. Further it is important that the information system is improved in order to make such considerations possible and that the information is used in the preparation of the decision basis.

The administrative structure of the University of Copenhagen is in a state of change. The only thing known today is that one of the results of this change will be a more appropriate organization of the economic and the academic administrations. The new law on the government of universities has provided the University with a number of new or reorganized collegial bodies on which are conferred different degrees of competence. However the role these bodies are going to play is uncertain. This will, to a certain extent depend on the administrative assistance that is given to these bodies. Furthermore their role will be determined by the demands from the bodies for the administrative assistance.

The analyses have shown that the main problem of the University is that there does not exist a well-formulated common policy for the University that will enable the evaluation alternative plans, either at the Konsistorium level or at the Faculty level. Regardless of which academic structure is chosen and regardless of which collegial bodies are set up, it will not be possible to solve the problems unless the objectives are made clear. By changing the administrative structure and the distribution of competence between different collegial bodies we are only taking one step forward in the direction of setting up a better basis for decisions than today.

It is necessary for the University - if it wants to survive as one University - to set up plans that coordinate all Faculties. Furthermore the Faculty must coordinate the Institutes (1). The University consists of five Faculties and a number of common units (e.g. the administration). Each Faculty or common unit can be said to constitute an activity. The University then consists of a number of more or less independent activities but with a common budget.

The planning procedure must be based on the following types of information :

a) A number of relevant alternative plans must be set up.
b) For each plan there must be a specification of the relevant consequences
c) Discovery of the decision-makers preferences with regard to consequences of a plan.

The problem here is the question of the preferences of the decision-makers in case of either the members of the Konsistorium or the Faculty.

It is a general feature in all planning that an acceptable result can only be reached through a cooperation between the decision-makers and the planners. It cannot be expected of the decision-makers to formulate a goal unless the planners have presented a survey of the consequences of a number of relevant alternative plans. On the other hand, the planners must base their work on different plans on a certain knowledge of the decision-makers preferences.

We can hope that a strengthening of the planning function at the University can force the decision-makers to express themselves more explicitly. The purpose of the project is then to set up some models that can be used by the planners to calculate the consequences of different preconditions introduced into the models. If the decision-makers are not satisfied by the alternatives presented to them, then they have to explain the alternatives of which they want to know the consequences.

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(1) The following is based upon : Inge Thygesen, Investment Planning - Improved Decision-Making Through Operational Research, Copenhagen 1971. Chapter 5.

PART III

THE GOVERNMENTAL AGENCIES

Chapter IV

BUDGETING, ECONOMIC MANAGEMENT AND PLANNING AT THE MINISTRY OF FINANCE

by

Jens N. Christiansen

Introduction

There exists no up-to-date, comprehensive, and official material on Danish budgetary procedures.

In this chapter we will give a broad outline of the parliamentary background, and, in some more detail, the administrative control procedures followed in preparing the Danish budget. Further we will show the difficulties raised when applying well-known economic theories to the steering and budgeting of both the total state budget and the educational budget. Examples of some ways of using better budget systems or improving the existing system will be given in the last part of this chapter.

According to the Constitution no state expense must take place without the previous consent of parliament. Thus in articles 45-47 the appropriation-authority is given to parliament, and the same articles stipulate some specific requirements which the budget must meet.

Article 45 states a deadline for submitting the budget bill - "not later than four months before the beginning of the financial year". This implies an annual budget, and it is futhermore a condition that the budget must be specified to some degree. By Royal decree the financial year runs from April 1 to March 31.

Article 46 states that no expense must be incurred without title in the finance law, the supplementary-appropriation law or a provisional appropriation law. Title according to common legislation is not sufficient,as only appropriation laws can authorize a minister to incur expenses. However, a parliamentary practise has developed so that supplementary appropriations are only brought up once a year after the end of the financial year. Supplementary appropriations are thus in reality subsequent to the incurring of expenditure. The necessary previous consent of parliament is obtained through the consent of the standing parliamentary committee of finance.

Article 47 gives the rules for the presentation of the state accounts to parliament. The accounts must be presented not later than six months after the end of the financial year.

Otherwise, the structure of the budget and the detailed budgetary and appropriation procedures are mainly fixed by administrative decisions and certain political traditions. In principle, this gives a possibility for prompt changes in the procedure though in practise changes are not very frequent.

The budget covers about 35 per cent of the Net National Product. Together with the budgets of the counties and the municipalities, about 45 per cent of the national income passes through the public budgets. The public educational sector accounts for about 15 per cent of that.

Budget and appropriation law

The budget is partly a calculation of government expenses and incomes during the financial year and partly a plan for the activities of the Government, and thereby a setting of priorities among the governmental tasks.

In connection with the regular control of the budget during the financial year and the subsequent auditing of the accounts, an evaluation of the effectiveness and efficiency of the activities is made possible. The value of the existing control procedures is discussed further below.

This budget cycle which is described in detail below is the core of the financial management process. The effective administration and control of expenditures is, however, only part of the demands which must be met by the procedures for financial management.

Thus the aim is an integration between the financial management function and the general state planning functions, partly by extending the time perspective of budgeting beyond the next financial year and partly by transfering existing plans into annual expenditure flows.

Finally, the total budget exerts a considerable influence on the general socio-economic development and is used as an instrument for this.

The budget, therefore, has several facets and its actual structure can be varied a great deal according to the emphasis given to its various functions.

By parliamentary adoption the budget becomes the finance law, and the sums allocated in the budget are put at the disposal of the various administrative units as appropriations, i. e. authorizations, to incur expenditures or receive incomes on the terms fixed in the budget. Formally, the appropriations are given to the individual ministers for specified purposes (for instance a university) and in turn delegated to the administrative unit in question.

In the budget a reserve is kept for new and unforeseen expenditures during the financial year, i. e. price and wage increases, expenditures in consequence of new legislation and expenditures for activities not envisioned or not sufficiently planned in detail at the time for submittal of the budget.

This reserve is not an appropriation and can ordinarily only be spent on the basis of supplementary appropriations, i. e. previous consent of the finance committee and subsequent inclusion of the amount in the supplementary appropriation law. In the case of wage and price increases this previous consent is implied in the appropriations in the finance law, so the supplementary appropriations for these are automatic adjustments.

The appropriations are instruments of management for the Government. By specifying in various degrees the programme of action to be carried out under an appropriation, parliament and the central authorities can exert more or less direction over the activities carried out by subordinate units. This direction ranges from only prescribing an end result on one hand to stipulating in detail the activities to be carried out and the resources to be used on the other.

In some cases however essential parts of a programme of action are laid down in the ordinary legislation or other directives, in which case the management through appropriations is only of supplementary kind or is in fact not operating.

Budgeting

When the budget is submitted to parliament four months before the beginning of the financial year, a separate publication, "Four-year budget, Estimates", is simultaneously published. This publication gives an estimate of the development of state expenditure, covering the next and the following three financial years.

The drafting of the budget and the four year estimates is done by the individual ministeries with the Ministry of Finance as coordinator.

In the spring months of each year the Ministry of Finance prepares for the Government basic budgets for the fiscal year starting April 1st in the year following and the subsequent three fiscal years. These basic budgets contain for each ministry and, within each ministry, for separate areas of expenditure, maximum budget figures, the so-called budget-frames. Not included in the budget frames are expenditures which in fact are not manageable through appropriations, primarily various subsidies where the amount and recipients are fixed by law (e. g. old-age pensions).

The material also contains ceilings for the number of Government employees at all levels in each ministry.

When the basic budgets have been reviewed and approved by the Government they are circulated to all ministries, usually in June, together with supplementary instructions for the preparation of the budget.

In the subordinate units (universities, and their departments and institutes) the budget preparations however will have started twelve to eigthteen months before the beginning of the financial year.

The draft budgets of each ministry are submitted to the Ministry of Finance in the beginning of September, where they are subjected to a careful evaluation and, through negotiations with the ministries,they are adjusted to conform to the general economic policy.

The four-year estimates, which are submitted at the same time are not appropriation proposals but estimates of the consequences during the next three years of existing and planned activities. These estimates are in this respect a supplement to the one-year budget and make possible a more comprehensive evaluation of the effects of larger investments and public expenditure in future years.

The management of the budgetary process

Throughout the process of planning - to the extent it takes place in the ministries - costs are assigned to plans,and the estimate of costs become more definite as the time for implementation draws nearer. The final phase in this process is the transformation of costs into expenditure flows, which in the budget process are related to specific financial years.

Through the fixing of the aforementioned budget frames and the ceilings for the number of employees, a rough setting of priorities does take place, and the frames force a further evaluation of existing programs and priorities in each ministry.

About 65 separate budget frames are determined covering about half of the total budget.

Two contrary considerations are taken into account in deciding upon the number of budget frames. On one hand it is desirable to give each ministry a possibility of adapting itself to changing activities, that is to operate with few and large frames. On the other hand it is advisable to operate with frames covering homogeneous activities, in order to obtain a clear connection between the development of the expenditures covered by the frame and the corresponding activity.

The budget frames normally fix gross-limits for expenditure, as the influence of the state budget on the real-economic resources, goods and services is of primary interest in this relation.

The ceilings for the number of employees - one for each ministry - are a supplement to the budget frames. They are intended partly to actuate a labour-factor-reducing activity through substitution with capital-factors, partly to force a more rapid rationalisation of activities of decreasing importance.

Budget frames and personnel ceilings are not always fully synchronized, which implies that the budget limitations work either on the amount of expenditure alone or on the personnel.

Of course, it is a basic requirement that the greatest possible productivity shall be achieved. This means that budgeting must be carried out according to the gross-principle. This implies budgeting revenues and expenditures.
On the other hand, the budget does not have the character of cost, and accrued budget consumption of stock, interest on and, depreciation of, capital and pension obligations are only shown in the budget for certain public corporations.

Personnel and personnel-costs

For that part of an appropriation which covers the cost of permanently employed full-time personnel a separate control of appointments is established.

In connection with the appropriations, for each governmental agency an upper limit is set to the number of employees in the different categories of personnel, and new positions can only be created with the approval of the Ministry of

Finance and a special advisory board, composed of members of parliament, representatives of the labour unions involved and civil-servants. This is a complicated machinery, operating in connection with the budget process.

The budget cycle

The periodic structure of the budget forms a budget cycle, which runs over several years. At a certain time it operates in terms of several links in the cycle. Schematically this is shown below, where year 1 represents the appropriation- (budget) year.

	Central budget administration (Parliament, financial committee and Ministry of Finance (M. o. F.))	Ministries (departments and institutions in the Ministry of Education (M. o. E.))
Medio year -1		Provisional preparation of the budget for year 1 in the institutions
Ultimo year -1	Analyses of the general economic situation and the available resources in M. o. F	
Primo year 1	Working paper to the Government about the budget frames for the year 1-4	Provisionel budget considerations in M. o. E.
	Negotiations	
July-Aug. year o		Preparation of the budget and budget estimates
Primo Sept. year o	Contributions to the budget and estimates for year 2-4 from the ministries to M. o. F.	
Sept. -Oct. year o	Review of the budget-contributions in M. o. F. and simultaneously review of suggested increases in personnel by the committee for the control of posts.	
	Review of special questions or problems	
Ultimo Nov. year o	Introduction of the finance bill for year 1 and the estimates for year 2-4 in parliament	Preparation of provisional amendments to the budget
December year o	First reading in Parliament of the finance bill and debate on the budget estimates	

	Calling in proposed amendments to the finance bill	
Dec. -Febr. year o	Deliberations in the permanent committee on finance	
Febr. year o	Proposed amendments from ministries to M. o. F. Review of those in the latter and forwarding to the permanent committee	
March year o	Second reading. Renewed committee review	
	Third reading and passing	
The appropriation year, year 1	Requests for supplementary appropriations are presented to the M. o. F. before being forwarded to the parliamentary committee on finance for approval	The ministries, and subordinate institutions use the appropriations. According to demands and needs the ministers ask the standing committee for approval of supplemental appropriations to be covered either through reduction of existing appropriations or by the reserves on the budget of the M. o. F.
Sept. year 1	M. o. F. works out estimates of the totals of the supplementary appropriation bill	Provisional working out of the contributions to the supplementary appropriation bill
Febr. year 1	Contributions to the supplementary appropriation bill forwarded to the M. o. F.	
March-Apr. year 1 - year 2	Review in M. o. F.	
	Negotiations	
Apr. year 2	Introducing the supplementary appropriation bill in parliament	
May-June year 2	Reading and passing	
June-Aug. year 2	Working out and publishing of the state accounts	Working out of contributions to the state accounts.

Economic management by the budget ?

For several reasons the finance bill is not a sufficient basis for an economic budgeting of the public expenses. The main classifications of the finance bill are based on the division of tasks between the ministers. The purpose of this is that the responsibility for the use of each appropriation must be placed only in one administrative unit.

The function of the budget as an administrative tool for the direction of a number of units and processes is thus clearly emphasized.

But if the budget structure is viewed as a means of locating each appropriation according to its economic or real-economic characteristic,in order to make possible economic analyses of public activities, then its usefulness is more limited.

There are a number reasons for this. The budget operates with a splitting up of the accounts based on the comparison of the kinds of expenses (investments, running costs, wages etc.) but not on the aims, or objectives for which those expenses are being incurred. Consequently, a comparison of the total expenses for a particular objective or programme is not possible.

The size of public expenditure is usually not determined through supply and demand, nor through any firm comparison of quality standards. This implies that one does not get any control of a possible non optimality of the decisions on expenditures in terms of the preference structure of consumers.

The difficulties in quality-rating of alternatives of expenditures to free public goods prevent a clear political weighting of the resource allocation.

The costs are not directly determinable from the budget. However an important problem is that the benefits cannot be assessed, because of the lack of a price or the uneconomic nature of the price.

Finally, the distinction between transfer and real payments - which financially look alike, but in real economics have a different effect on the resource allocation - is not always clear.

Thus, the total advantages and disadvantages in decisions on expenditures are veiled.

As a basis for economic management the budget by itself is of limited value. It is obvious that it is possible to influence the general economic activity, but management based on economic considerations is only roughly possible and is without reliable possibilities of control.

The following remarks are not especially related to the budget but to more general economic considerations.

The starting point of most recent considerations on economic budgeting in the public sector has been micro-economics. Broadly speaking this concerns the economic behaviour of the individual units (persons, business, institutions).

Two questions immediately arise. Micro-economics is a newer approach and, in its content, not as generally accepted as macro-economics, though this does not necessarily make it less reliable and operational than macro-economics. In addition, a long and presumably unfinished discussion has been going on as to what degree the private-economic optimum criterion can be directly transferred to public activities. The attempts towards this are numerous, and it is often claimed that the uncertainty of using micro-economic theory in the public sector is hardly greater than when applied to private activities.

Micro-economics

Classical micro-economics has three elements which may be looked upon as relevant in this connection : the static analysis of efficiency, the maximization of investment decisions, and the influence by the public sector.

The static analysis of efficiency deals with the way in which short term profit of an activity can be maximized : two typical approaches will be mentioned here.

Firstly, one can deal with dispositions based on choice between alternative combinations of input which all lead to a defined output (i. e. cost minimization). Secondly, one can deal with a choice between different combinations of outputs (profit maximization).

These two lines of action are not independent of each other. Thus the cost-minimization is a necessary, but not sufficient condition for profit-maximization. Often the cost-minimization is understood as the smallest possible costs, no matter whether the resulting proceeds are of a relevant size or not ; and as a result no consideration is given to "total-cost-minimization". The evaluation of the output - which in most cases must be the main goal - is not shown in this analysis.

With a minor modification it is possible to identify the same fundamental point of view in the traditional, strongly specified budget, which was input-dominated (which means that it almost only dealt with costs), contrary to the frame-system, which is an attempt to make budgeting output-orientated, i. e.

including evaluation on the basis of a given amount (frames and ceilings) of resources.

The naive profit-maximization criterion has been heavily criticized. Especially, the assumption of a fully competitive market with full transparency and without monopolies has been a serious stumbling-block for the use of the theory. In the case of incongruity between the price of the product and its marginal cost (i. e. the cost of the last produced unit), the resource-allocation will not be optimal.

For public goods - such as educational activities - price setting is seldom possible and an evaluation of the product must be random. At most one can hope that a political goal lies behind an evaluation, so that the "price" is given from a political estimation of "the needs of the community" for the goods in question. It must be noted that this does not avoid the weakness of the method.

A number of organisation-theorists have also claimed that profit-maximization, even in private enterprise, is not the only goal - often not even the primary one - but that goals like growth of trade, growth in number of personnel or general prosperity among the workers are superior goals.

A third serious objection has been the presence of external economies or diseconomies, i. e. the effect of the costs for the individual activity and on the whole community (for instance by the firm's "wearing" or contamination of collective values). Finally, the whole analysis is of a short-term character and therefore hardly useful for real planning.

Profit-maximization in investment behaviour is also a set of rules developed in private activities. A later example is the discounted cash flow method. The purpose of this method is to illuminate the optimal allocation of given resources to a desired production in proportion to alternative allocations - without considering the already existing amount of resources bound for fixed use. A time preference is included so that later returns are estimated lower than earlier returns. This time preference does not make the model less static, as the outline for the time preference, expressed as a discount rate, still takes place at one and the same time ahead of the appearance of the returns. Although the theory can be used for longtime-considerations, it is static in character and implies the same uncertainty as mentioned earlier.

It is the characteristic of a "purely public good" that any amount available is for the disposal of anyone who demands it. In addition a single consumer's use of the good normally does not interfere with the possibility of others using it.

The good can be called "excludable" if, without any great practical difficulty, it can be transferred into a priced good for which one has to make a payment. Education - and health provisions - are goods of this kind. Also, the use of roads could be thought of as a public good which has to be payed for. On the other hand, public goods like national defence and the police-system can not be dispensated in accordance with individual payment.

Another reflection concerns the "rivalry" of users in the demand, i.e. how much on person's use of the resources reduces the possibility of others using it. Education also belongs to this category.

An example of both non-excludability and non-rivalry is national defence ; while, for instance, the radio and television are excludable but do not at the same time cause rivalry ; whereas education is characterized by rivalry as well as excludability.

Can this distinction be useful in educational planning ? Education is a public good which could be payed for and thus has a price. The rivalry according to certain views does favour the fixing of the price. The problem is to find the right price, as it is hard to imagine the determination of the price in a classical market. For several reasons such a market does not exist - and will never exist.

Education is partly a private and partly a public good. Although it is possible to make a division between the private (foregone income and other costs) and the public (salaries, other expenses, investments buildings) costs, such a possibility for making a clear distinction between private and public does not exist on the revenue-side. Apart from the private advantages derived from higher wages there normally exist "external economies", i.e. advantages which through the educational activities are spread to other than those educated. Thereby the notion of effectively allocating the resources gets another content and may cause a weakened rivalry. Also the excludability may disappear, as a fixing of the price will be far more difficult. The determining point of view will be that this automatic spread of the advantages is a strong argument for education to be payed by the public.

Meanwhile, the traditional efforts from the public have been more devoted to the control of the legality if the budgets than to their economy. This practical point of view has produced a budget which especially the accountant and the auditor could use in registration and control, but which is of little use in making allocation decisions.

Given the background of growth in the public sector a greater interest on returns from the purpose of education would emerge. This brings one to the cost-effectiveness point of view which enables one to compare one activity with the other. The interest which until now has been concentrated upon costs is shifted to the output on the resulting problems of resource allocation.

Cost-benefit analysis

When considering project evaluation, the technique of cost-benefit analysis is used as an instrument for a comparison between the costs and revenues of a given activity. From experience the definition of the relevant costs is one of the difficulties. This difficulty is perhaps not the most important one. The main question concerns the indirect costs, i. e. the costs which are incurred by the students and the community because wage incomes are zero (or very low) during the period of study. These costs do not appear in the budget.

The other, and still greater, difficulty lies in the evaluation of the benefits. In analysing benefits from education one is faced with insuperable difficulties which will be mentioned later. First, we will summarize the conditions which according to Prest and Turvey(1) demand closer consideration on the theoretical level :

1) The definition of the project. A theoretical definition very seldom causes great difficulties whereas a practical definition in the light of the existing variables of decisions is normally far more difficult. The project needs to be delimited and defined in such a way that it is in accordance with the possibilities for making decisions within the existing decision-structure.

2) External economies and secondary benefits. It is often assumed that countries which spend a lot on education gain advantages which cannot be measured in monetary terms. For instance, a higher level of political consciousness, more cultural goods, a healthier population, an environment stimulating intellectual work and new knowledge, a more flexible labour force and a number of advantages for future generations.

3) The extension of the benefits over time. As previously mentioned the

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(1) A. R. Prest & Ralph Turvey, "Cost Benefit Analysis : A Survey", Economical Journal, LXXV, 1965.

revenue of education is very long-lasting. This gives two possibilities of measurement. One can either try to make a judgment on the value of all the years and weigh them according to a certain time-preference (rate of interest). Or one can be satisfied by seizing the measurable and definite short term benefits and, thereafter, either forgetting the longterm benefits or adding an estimated value to the measurable benefits.

The existence of externalities is the primary characteristic of social cost-benefit in relation to private cost-benefit. Many attempts have been made to get a definition of this - best known are those made by Becker, Blaug, and Dennison, who, independently of each other, have reached results which are at least not contradictory, although they differ considerably. Simply to omit the calculation of externalities would be such a strong underestimation of benefits that the method is invalidated. The situation may result where the private cost-benefit gives an unprofitable result while the social cost-benefit makes it quite profitable. (The opposite is said to be the case today.)

The calculations of the costs often leads to long discussions. A workable definition seems to include three descriptions of costs : 1) a number of expenses in kroner ; 2) the costs by using time - these are most often not evaluated - and 3) the disutility of a given activity. One can argue that the last item automatically will influence a selection based on the size of the first. Therefore, it can be omitted. Disability or inactivity has, by the way, never been determined. Meanwhile, the application of time is a significant cost-factor - whether it is measured in cash or not.

From the financial considerations of the state - and this is probably a more relevant judgement of the existing budget-process than a real (resource) economic consideration - the income-transfers (especially grants and loans) have to be included. An interesting field is the substitution interval between the time-costs and other costs, and some reflections on this may seem relevant. The fact that the tendency of the substitution goes from real-costs (time) towards transfer-costs (scholarship and cheap loans) merely implies a greater economic profit.

A definition and estimation of the rate of return has been a very difficult problem in nearly all cost-benefit analysis. This factor is normally split up into two parts. The first expresses a social, marginal time-preference for giving up present consumption in favour of future consumption. The second measures the rate of return expressing the social opportunity cost of capital. This further gives the value of capital in alternative applications. Providing a fully competitive capital-market the market-interest evidently will reflect both. The knowledge of such a rate of return is hardly a condition for using the method. Instead of this, one can operate with alternative return-values to find out at which level the investment changes from being unprofitable to being profitable.

Regardless of this one comes back to the everlasting problem in cost-benefit analysis in the public sector : the costs must be paid by a purchase in money while benefits are only seldom sold. As a result, undoubtedly, the cost-benefit arguments have evoked a bad conscience in several budget makers in the public sector who are only concerned with costs.

Output budgeting

With these background considerations, actual output budgeting may be a central question. The basic idea is here to gather all the cost-elements of a well defined task(function or project) in order to make a direct weighting of the project and costs. Whether the weighting should be made on a cost-benefit principle or on some other principle is not fixed in advance by the idea of output budgeting but depends on the structural method for the activity in question.

The division into functions will cross the administrative or jurisdictional lines. This need not be a principal - but may be a practical hindrance for a splitting up of the differents functions in the budget. More likely, the difficulties are engendered by the traditional system of information, based on the principle that, primarily, the formal application of money shall be controlled. Whether the money is spent in an efficient way and for well defined goals, and whether non-monetary costs and benefits are involved, are questions which the present accounts are totally unable to take up. In addition, for making decisions it would be convenient to know a possible discrepancy between marginal and average amounts on the input- as well as the output side.

The budget estimate

Output budgeting is an innovation of the 60's. Previously, budgeting was largely incremental, based on the latest accounts. During the late 60's a special interest for the expansionary areas of expenditure began to show. From this, central direction of the budgetary process was introduced, which had as its most outstanding results the budget frames and the ceilings for the numbers of employees.

A condition for carrying out the central direction is long term budgets. With this a more relevant time dimension is put into the budget procedure. Governmental action can seldom be evaluated solely from its effect in the first year. The future consequences therefore ought to be displayed before decisions are made, i. e. before an initial appropriation is given.

But here two difficulties arise. In the first place the finance bill is only annual, and according to the Constitution it cannot be otherwise. Secondly, there is a political dislike of entering into large future commitments. Often there has been an ambiguous attitude in decisions on major projects caused by a desire to start projects of a long-term character, accompanied by a dislike of weighing the economic consequences in the long run.

The budget frames are fixed in advance by the Ministry of Finance and may not be exceeded in the actual budgets. The frames give quantitative limits for qualitative evaluations, and these evaluations are, in principle, delegated to the individual ministries. Formally, it is not practised very much. Marginal budgeting is typical. A reorganization towards program-budgeting, which is made possible by the frames, has not been utilized to any extent so far.

The ceilings of the number of employees, too, are established in advance by the Ministry of Finance. They express fixed maxima for employees of each ministry. The purpose is to moderate the increase in public consumption of fully employed persons.

The control of the ceilings is carried out by the Committee for Control of Posts and the Ministry of Finance, and gives both a powerful role. At the same time this can lead to an unfortunate centering in the budget process on the salary expenditures and a neglect of the possibilities for substitution between salaries and investments or salaries and other costs.

The instruments of management are thus concentrated in 1) control of the ceilings of positions or posts, 2) fixing the budget frames, and 3) control of new legislation. The political lack of interest in stating precise goals has, as its effect, a certain negligence in the preparation of the budget estimates. To a certain degree the budget estimates may turn out as a "piling up" of appropriation bills without goals. Finally, even the longer time dimensions of the estimates are too short a time-perspective for many projects.

Perspective planning

In the autumn of 1968 the Government initiated a study of problems relating to the establishment of long-term priorities for public expenditure, including the interdependence of trends in public spending and national economic performance, in order to strengthen the long-range planning of legislation and central government expenditure.

A working party, set up to organize and implement the study, was asked to submit a report on its findings within two years.

In January 1969 the working party issued initial guidelines for the participation expected of government departments in the conduct of the study. The guidelines laid down common assumptions for trends in population, manpower and economic growth as well as provisional directives for the contributions to be made by the individual departments. The departments were asked to describe the movements recorded in recent years, especially for their major fields of expenditure and the factors determining the use of resources, and to forecast trends in resource utilization up to 1985 in the light of existing legislation and the current debate on objectives.

Since the late 1950s, Denmark has experienced an economic expansion of unusual dimensions. Throughout the sixties, high levels of employment and rapid improvements in productivity made total output increase by an average rate of 5 per cent a year while the work week was reduced.

Such a fast rate of progress inevitably generates tensions and problems, and resistance to change may easily give rise to undesirable side effects. One of them was inflation. Another was the growing external deficit. Both may be seen as corollaries of heavy domestic demand pressures which, while having probably contributed to the acceleration, also show that the forces thus released were difficult to control.

One of the principal aims of the study was to consider whether, and under wha conditions, the growth of prosperity could be maintained.

Even if there are no indications to suggest that technological progress will slow down, developments at the beginning of the seventies appear to be shifting in a manner that will have unavoidable repercussions on the formulation of economic policy. These difficulties will involve particularly heavy burdens in the next years.

The principal aim of the long-range study was to elicit information which could serve as a guideline for current policy-decisions. The absence of such information had been felt before, but more exacting conditions have made it increasingly necessary to provide such information.

Since most decisions on economic policy are ipso facto strongly influenced by the conditions prevailing at the time when they are taken, they are generally based on a fairly limited context although they usually reach far into the future and affect wide segments of the economy. Hence, there is a need for a wider and more coherent perspective of the factors to be considered when important decisions on economic policy are to be taken.

There is, in particular, a need for projections of present trends and forecasts of potential changes. The purpose was in fact, to make such broader and longer perspectives available as background data for planning of significant elements of economic policy.

Seeing that projects started now, (e.g. traffic installations, universities and hospitals) will still be in operation for many years of the next century, it may well be asked why this study does not reach beyond 1985.

The answer is that in a world of rapid and sweeping change such studies would be of a very academic nature. Speculations reaching more than fifteen years ahead might serve a useful purpose in the planning of a development programme for a backward community, but they would not be of much value as indicators of potential trends in a wealthy country like Denmark. Even parallels with developments in the United States do not offer many clues. Studies with very long perspectives would be more in the nature of a research project and could, on present knowledge, offer little guidance for decisions that must be taken within a short span of years.

So the aim of the present study is the less ambitious one of providing a wider background for current decisions than the limited perspective of 4-5 years that is a typical feature of medium-term budgets.

The study is based on the general assumption that economic growth in the world around us will be maintained at a high rate and without excessive fluctuations throughout the period from 1970 to 1985.

The rise in public expenditure which the report suggests will be rather slower than it was in the sixties, but the physical resources available for expansion of employment and production will also diminish. The sixties demonstrated that it is much more difficult to keep the economy under control when the public sector expands at a faster rate than output during an economic expansion, which, in itself, gives a strong impetus to private consumption and investment. This tendency is likely to persist in the coming years.

In the establishment of priorities for public expenditure it should be borne in mind that public sector activities cannot be evaluated solely in the light of their immediate relevance to welfare.

Education is a significant example of problems encountered in the assignment of priorities,because it has vital bearings on the performance of industry and on the quality of public services and also because it is, in large measure, the foundation on which individuals shape their lives. Education is, in fact, an integral element of social and cultural progress.

The sixties witnessed an expansion of the education sector of such dimensions that it now takes close to 6 per cent of the national product. Moreover, many more persons over the age of 17 stay in education and do not enter the labour market. The resulting loss of production is particularly noticeable for those parts of advanced and adult education which extend over several years. By 1985, the total expansion of the educational sector will have reduced the total number of man-years available by 85, 000-100, 000.

This loss of production, representing several billion kroner, cannot be added directly to the amount allocated for education, because that loss is a precondition for the increase in productivity achieved through education,which, therefore, is assumed to offset the entire loss - though with a considerable time-lag. If, however, studies can be shortened without loss of quality in education, direct gains will evidently be achieved through reductions in the cost of education as well as in the loss of production.

Such changes have, in fact, been proposed in the contribution received from the Ministry of Education for this long-range study of economic planning. These proposals represent the first attempt ever made to draw up a general plan for the entire educational system. This work covers such a vast range of problems that the preparation of detailed programmes and curricula had to be deferred at this stage of the study. When political approval has been obtained, this work must play a central role in the further planning operations. For the purpose of this study, the special value of the Ministry's contribution is that it sheds light on possibilities of building up a system of education which will require less resources and thus involve a slower rise in expenditure than expansions along traditional lines would.

In other parts of this study it has been assumed that over the next 15 years a large proportion of school leavers and graduates - probably no less than one third - will find employment in the public sector. The great majority of them will go into social or health services. This will require rapid expansions of those parts of the education system that prepare students for such work, which mostly requires studies of medium length (3-4 years).

The education sector will, incidentally, expand vigorously by its own momentum and will therefore need many graduates for its own use, especially for pedagogic teaching and training.

In the field of education, planning must of necessity cover very long periods. Many circumstances will change during the time-lag between the approval of plans for expansion and the stage when school leavers and graduates join the labour force. Flexibility is therefore essential, both in the education system as a whole and in individual fields of education. To that end, shorter basic study programmes and extended systems of inservice and postgraduate training can be useful.

An expansion of the educational facilities is a precondition for implementation of several of the existing programmes for extension of public services. Central planning authorities must therefore keep the rates of expansion foreseen for individual sectors consistent with the teaching capacity that can be provided for them.

It was not within the working party's terms of reference to suggest detailed guidelines for the assignment of priorities. That is the primary responsibility of the Government and the Folketing (parliament). The material presented in this study is intended to raise a number of questions for consideration in more detail.

In conclusion, the working party emphasizes that it is a fundamental condition, if changes in existing priorities are to be made on an adequate basis and are to have the intended effects, that the necessary instruments of management and control are provided for that purpose. Lack of comprehensive background information and inadequate regulatory machinery was, in fact, among the factors which contributed to the steep rise seen in public expenditure during the sixties.

The principal subjects for further deliberation in connection with problems of management and control are, briefly, as follows :

- the study revealed an unmistakable need for more and better planning in government departments and agencies ;

- the study did not result in any concrete plan, and the chief value of the findings will be the extent to which they lead to continous planning activities, in the course of which long-range tentative projections will be followed up by more specific planning for the next few years ; these activities can also provide a firmer basis for the current preparation of central government budgets ;

- the current flow of information available to government departments- and, consequently, to the Government and the Folketing - is definitely inadequate and received with much too long delays ; even the information that is available is not always obtained and analyzed sufficiently to form a useful basis for decision-making ; it has been suggested - often enough - that the purely administrative functions should be taken out of government departments in order to enable them to concentrate on overall and general management functions within their respective spheres of responsibility ; these suggestions should be carried into effect ;

- the inter-departmental exchange of information is inadequate ; this is no doubt a corollary of a deep-seated Danish tradition for every government department to be regarded as a separate and self-contained entity ; it is equally important that relationships between the central government and local government authorities should be taken up for examination with a view to ensuring a better coordination of decisions ; local goverments are responsible for a large and growing share of public expenditure - so large, in fact, that planning for central government spending alone will become insufficient ; it must be possible, without encroaching upon significant intrinsic values of local self-government, to bring local government budget work within a comprehensive framework for the planning of all public sector activities, commensurate with the total potential of the national economy.

Chapter 5

THE MINISTRY OF EDUCATION AS A PLANNING AGENCY

by

Niels Hammer-Jespersen

Summary

In the first section it is argued, that the intention of the Ministry of Education in joining the project was a desire to establish a better budgeting - and planning - procedure than has been used up till now.

In the two following sections the organization of the Ministry and the budget-ceilings are discussed.

After a short recapitulation of the budgeting procedure in the Ministry of Education we discuss some problems arising from the relations between the Ministry of Education and the Ministry of Finance. It is argued that the control that is exercised by the Ministry of Finance seems too comprehensive, given a budget-ceiling system. Further it is concluded that the Board for the Control of Posts is superfluous since the use of manpower is also governed by a ceiling.

Other problems arise from the fact that all post-secondary education is not organized in the Ministry of Education and hence does not belong to a common ceiling. Some of the problems, especially in planning, will probably be avoided by the implementation of a new structure organizing the institutions in centers for post-secondary education.

Finally it is concluded that the Ministry as well as the institutions of higher education are best served by cooperation and an improvement of the administrative ability. We assume that a major step in this direction is taken by the tendency to organize centers of post-secondary education.

The Ministry's intentions in joining the project

When the Ministry of Education joined the project it asked for an investigation of the possibilities to improve the quantitative bases for decisions concerning budgeting and planning of higher education.

The desire was the creation of a quantitative budgeting-and planning procedure that would give the higher administrative and planning bodies at the institutions, as well as the central administration (the Ministry), the possibility of evaluating the wishes and the needs of the individual Institute, Faculty and institution (University) with reference to the composition of the total budgets in respect of the educational and research policy that is carried out. It was especially emphasized that a basis for calculating the budgetary effects of alternative educational plans be created.

The organization of the Ministry of Education

The Ministry of Education is organized in one departement and four directorates((1) the primary school and teachers colleges, (2) the secondary high school (3) the vocational educations and (4) the continuation schools. The department is organized in three divisions, one covering general matters from the directorates and legislation in those areas, another covering building construction for institutions under the directorates and a third division for the higher education.

Matters concerning building construction for higher education is placed in a special administration partly outside the Ministry.

The division for higher education consists of three offices : one for budget and personnel matters, wages, appointments, promotions and general questions; one for curricula and examination rules, admission rules and planning (4-years budget, manpower programs etc.);and one for international relations.

Budget-ceilings allocated to the Ministry of Education

In accordance with the administrative structure of the Ministry budget-ceilings are set for :

1) The Ministry itself including grants for a number of international activities.
2) The primary school, teachers colleges, continuation schools, secondary high schools etc. , one ceiling for running costs, another for construction.
3) Research and higher education, one ceiling for running costs, another for construction.
4) Vocational educations, one ceiling for running costs, another for construction.

The manpower-ceiling is allocated to the Ministry as a whole. The reasons for this are discussed in the previous chapter.

Budgeting procedures in the Ministry

When the Ministry of Education receives the ceilings from the Ministry of Finance, it first of all has to allocate the manpower-ceiling between the different divisions and directorates. The research and higher-education division gets approximately 70 % of the total ceiling ; in 1971-72 this amounted to 13,693 positions increasing to 14,190 in 1972-73.

When this is done, the division sets up a proposal for distribution of the ceilings among the institutions belonging to the area of research and higher education. The criteria underlying the distribution for 1972-73 was a desire to avoid general decreases in standards. The reason for this rather pessimistic starting point was a severe decrease in the expected manpower-ceiling for 1972-73.

For 1971-72 the Ministry requested 13,863 positions for the research and higher education and 13,693 were accepted by the Ministry of Finance and the Board on Control of Posts, and at the same time the ceiling was lowered from 13,863 to 13,693 which was a new procedure. Up to now the Ministry of Education has had disposal over rejected positions which meant that one year after wards it could at least reallocate rejected positions together with the increases up to the new ceiling. The expected ceiling for 1972-73 was 14,596 which was an increase of 903 positions compared with the number of accepted positions for 1971-72. However, only 14,190 positions can be realised for 1972-73 leaving an increase of 497 positions, a reduction of 406 in the expected positions. The 497 new positions were not enough to secure an unchanged standard at the institutions of higher education if we accept that the measures of standard are (1) the expected number of students per tenure teacher-position, (2) the ratio between technical and secretarial assistance and the tenure teacher-positions.

Another problem is that only the universities in Copenhagen and Aarhus have free entrance, the other institutions have restrictions on admission. The Ministry therefore allocated no new positions to institutions with no increase in enrolment. Secondly, in order to secure a minimum of relief to the open-door universities the Ministry allocated a number of positions to institutions with restrictions, but planned increases in enrolment, the number of positions being large enough to secure at least an unchanged student/teacher ratio. Finally the remainder was allocated to the open-door universities.

The budget-ceilings were set up according to the number of allocated positions, and then corrections were made for differences between the number of teacher-positions required for an unchanged student/teacher ratio and the expected number of teacher-positions requested out of the total number of positions allocated to the institutions - so that it was possible to buy a number of non-tenures.

The next step is that the institutions prepare their budget proposals, which are then forwarded to the Ministry of Education. The proposal from the University of Copenhagen will then contain a distribution of the budget-ceiling on the accounts that are used in the budget and a distribution of the positions on the different kinds of manpower used at a university. The procedures at the University are discussed in Part II, chapter 2.

The different proposals are then gathered in the Ministry of Education and introduced into the total proposal for the research and the higher education.

Some problems

The major problems seem to arise from the fact that the Ministry of Finance does not fully accept the consequences of the budget-ceiling system and from the way in which proposals for new positions have to be handled.

First of all the Ministry of Finance is not very fond of contingency funds outside its own budget-accounts. Secondly every new position has to be allocated to the lowest possible level (the Institute) when it is proposed and it must be accompanied by a careful explanation of why it is proposed and a description of the work that is to be done.

The official projections of the student population seem fairly good as long as institutions and major study fields (e. g. Social Science) are concerned. However, inside these major fields many things can happen from one year to the next. The number of students in one subject can show a sudden and sharp increase, but it is often at the expense of another study in the same major field. If all positions are allocated beforehand, then troubles will arise which could be avoided if it was possible for the institutions to set up pools of new positions for the major fields and then allocate them to the individual studies when the students show up.

This is the same reason that lies behind the Ministry of Education's desire to hold back money as well as positions as contingencies. To this is added the fact that a number of plans for new activities exist but not in such a form that a proper budget can be set up. The Ministry has to estimate the costs and the manpower needs and to keep appropriate contingencies.

But the Ministry is not able to use these contingencies without acceptance from the Ministry of Finance as well as from the Parliament, although the Parliament has accepted the contingency funds (on a special budget-account). However, the parliamentary control over the public's use of money and manpower states the reason for double parliamentary acceptance. But we see no reason that the Ministry of Finance has to be involved, unless it expects that the Ministry of Education will not respect its ceilings. But if this is the case there is no reality in the system of budget-ceilings. The same thing goes for the positions. Why should a central body (the Board on the Control of Posts) accept the establishment of every new position even inside the manpower ceiling ? There seems no reason to believe that either the Ministry of Finance or the Board on Control of Posts should be more competent to evaluate the proposals for new teacher positions than the Ministry of Education ; at least they do not tell anyone about the criteria that they use in accepting or rejecting new positions. Therefore, the existence of the central control in the Board on Control of Posts apparently often results in the fact that the institutions avoid difficult choices that really should be theirs. We need therefore to say that the Board on Control of Posts is superfluous and that the control in the Ministry of Finance is too comprehensive.

Organizational problems

In the planning of higher education one has to be aware of the development of other institutions of the post-secondary education sector. A number of these are under the jurisdiction of the directorates, for instance the education of teachers for primary schools, teachers for kindergartens, the Schools of Economics and Business Administration, and others belonging to different ministries, e. g. the training of architects covered by the Ministry of Cultural Affairs, of social advisers covered by the Ministry of Social Affairs, of nurses covered by the Ministry of the Interior.

As these different types of educations belong to different directorates and ministries they also are subject to different budget-ceilings. This makes it difficult to look upon the post-secondary educations as a whole. Further we cannot be sure that the other ministries give full attention to educational aspects when they allocate their ceilings, of which only a minor share goes to educational purposes.

The Ministry of Education is fully aware of this and for its own part considerations on the internal structure are going on.

Furthermore there is a clear tendency towards organizing new education and expansions of existing education in centers of post-secondary education. By doing this all kinds of institutions will be situated in a center irrespective of their legal attachments. The centers will be organized with a Governing Board representing institutions belonging to the center. In this way we hope that we shall be able to avoid most of the problems arising from the existing organization of the post-secondary education.

Conclusion

An improved basis for decision-making at the ministerial level will be an advantage for institutions as well. It will strengthen the position of the Ministry of Education so that it can overcome some of the weaknesses in the budget-ceiling system as it is administrated today.

The task for the Ministry of Education is at the same time to take care of the interests of the public and the institutions of higher education. The interests of the institutions of higher education are best looked after if a basis for decision-making can be provided that will strengthen the position of the Ministry of Education. The interests of the public must be perceived as positive with the only restriction being that they are subject to scarce resources. The Ministry of Education then has to allocate the scarce resources between the different research and educational activities, so that we at the same time fulfil the political objectives and coordinate the activities such that the resources are used in an efficient way (minimizing the wastage). This task can only be carried by a central authority that has the necessary general view. To make this a best possible solution it will be necessary to obtain the positive cooperation from the decentralized institutions.

The Ministry of Education is now considering reform in its internal structure with regard to problems that need to be solved. Secondly, there is a tendency towards organizing the institutions in centers of post-secondary education, which in itself should improve the administrative capability at the decentralized level.

PART IV

THE DESIRED UNIVERSITY STRUCTURE
AND
THE REQUIRED PLANNING TOOLS

Chapter 6

SIMULATION MODEL OF A UNIVERSITY

by

Niels Hammer-Jespersen

Summary

A university can be looked upon as a system that is governed by a set of parameters or technical coefficients. By concentrating its discussions on the parameters the Konsistorium will identify the specific causes for demands on resources, and it should be able to calculate the consequences of changing the parameters which are within its control.

The simulation model is based upon a student-flow model. The input of students is looked upon as given from outside the university. It will then be the transition coefficients that determine the total number of students, in faculties as well as in the aggregate. The number of teachers and then the teaching capacity can be calculated directly from the number of students, when information is given on student/teacher ratios and structural parameters determining the composition of the staff. Given the number of teachers and other employees it is possible to calculate the budget of the university. Finally a staff-flow model is set up, which makes it possible to see if all promotion positions can be filled or not, and at the same time ensures that the staff is not reduced by more than those leaving voluntarily or retiring on a pension. A simulation model can be used to calculate the consequences of alternative developments in the parameters. Furthermore it is also possible to calculate the future consequences of present structural changes. The university must then evaluate the consequences and decide on them. The problems around the simulations are discussed as we present four different kinds of simulations : What are the consequences of an arrangement which reduces the student pressure on one or more faculties ? What will a change in the study plans lead to ? Can the model be used in the case where we want to reallocate resources ? As the last illustration we will discuss the question of how long it will take to carry out a new ratio between professors and other tenure teachers - this new ratio creating a number of new promotion possibilities.

The preconditions for the practical use of a simulation model are the following : First, which parameters are exogenous and which are endogenous. Second, it is decisive that the model be based on a complete and detailed analysis of the structure which it is supposed to describe. Third, the continued work with the model demands that the information system is always up to date. Therefore we need to have a discussion of the information system to see whether it is adequate or not in its current situation. If it is inadequate then we need to find out the weak points.

In the last sections of this chapter we present the mathematical formulation of the simulation model. The first one contains a complete list of parameters indicating if they are exogenous or endogenous. On basis of the mathematical formulation the model has been programmed for the computer using the IBM 360/75 FORTRAN IV.

Introduction

A simulation model (or a forecast model) can be constructed in such a way that it can calculate the budget for the university.

The values of the parameters are the governing elements of the model. Decisions at the university should concern the parameters, whose values are under control. The model can then calculate the consequences of postulating alternative values of the parameters.

The Konsistorium (or faculty etc.) can ask the administration if it is possible to realize a certain set of parameters. The administration can then calculate the consequences and answer yes or no depending on the restrictions of resources.

With regard to the parameters one critical question is if a change in one of the parameter will lead to a change in one or more of the other parameters. For instance a change in the appointment-policy can lead to a change in the employees' attitude towards the university and this can affect the frequency with which teachers leave the university.

However, as a starting point the individual parameter-values are supposed to be in balance. Any work on the model will then be under a ceteris paribus condition. Even if it is suspected that the ceteris paribus-restriction is not fulfilled, then it is still possible to use the model. In each simulation run it is possible to calculate the consequences under a ceteris paribus condition as well as under successive changes (reactions) in the other parameters.

Decisions on the parameters (under control) can be made at different levels inside (and outside) the university. It is important to notice that every level has an influence on the actual value of a parameter. The model as it is set up here is concerned with the Konsistorium- faculty-levels. However, the paramaters are fixed (or should be fixed) by negotiations between the two levels, but the basis for these negotiations should include information from levels above the Konsistorium (e.g. the Ministry of Education : Total ceilings for money and manpower) and below the faculty-level (e.g. information from institutes on number of supplied lecturers and use of teachers etc.)

To make sure that the model can work in practice it is necessary that relevant information is available in a usable form. The need for information will be discussed in a later section, but it is important to notice that all information on the same matters should be comparable.

An important purpose of the model is that it enables one to identify the causes for demands of resources. For a given input of students,a given structure will lead to a certain demand for resources. As resources are restricted, the situation can be either that they are not sufficient to fulfil all demands or that there will be excess resources. The university should then be able to find the necessary savings, which for a given criteria will minimize the disadvantage of not being able to fulfil all demands,or they can choose those expansions which give the best improvements.

It is however necessary that the decision-makers have criteria on which they can evaluate a configuration as "good" or "less good". Only on the basis of the criteria is it possible to decide which things should be taken into the budget and which things should be rejected.

It is obvious that the above mentioned must lead to a program-budgeting system. However it need not lead to a real PBS and it can be used within the existing Danish budgeting system. A real PBS assumes an output-orientation, which makes a measurement of the output necessary. The consequence of using a simulation model can only be said to be program oriented, and a proper measurement of output is not necessary. It is required that criteria be set up which can be used as the basis for setting priorities between alternatives.

To set up relevant criteria we must however identify the factors that have an influence on the output. The problem for the decision-makers is then to attach weight to these factors as an expression for the extension of their influence on the output.

Such factors could be class-sizes, number of hours per class, duration of courses, the number of teachers per class or student, the type of teacher used for a given kind of teaching. The priority of an arrangement will then depend on the weight attached to the individual element in the concrete case.

The things that influence the output will be expressed in a number of parameters of the model. A change in these parameters will express a change in the weighting and then express a change in the priorities.

The model is based upon the existing structure of the University of Copenhagen and its surroundings. This is a typical hierarchical system : A Ministry of Finance and a number of different special ministries, a ministry of Education with universities and other educational institutions under its jurisdiction, the University of Copenhagen consisting of 5 faculties, each faculty with a number of individual institutes.

The model is actually placed at the Konsistorium-level (see Part II) with the Konsistorium as a decision-maker and the faculties claiming for resources. A similar model could be set up on any other level : an example could be that when the Konsistorium has made its decision, then the faculties must start negotiations with the institutes on the basis of the resources allocated to the individual faculty.

Further is should be mentioned that the model is not bound to the existing structure, but it can easily be changed to cover the proposed structure under the new law on the government of universities. The only restriction is that the structure shall remain hierarchical.

The simulation model

In this section we will give a verbal presentation of the simulation model together with some results from the test runs of the model using actual data from the University of Copenhagen. A mathematical abstract of the model will be presented in last section of this chapter.

a) The University of Copenhagen consists of five faculties and a group of enrolled students who have not yet chosen either their study or their faculty.

The basis of the model is a student flow model which, for each year, gives a distribution of all students among faculties, levels of study, number of dropouts and graduates. This part of the model is based on the number of newly enrolled students and the transition coefficients.

The levels of study are assumed to have a duration of one year each. The students enrolled at level 1 in a faculty will, with a certain frequency, after one year pass on to level 2 (survivors), or remain at level 1 (repeaters), or drop out. The repeaters will then after one more year at level 1 have the same frequency to pass on, remain or drop out as the year before. The survivers will have another frequency of passing on to level 3, to remain at level 2 or to drop out, and so forth. At the last level (6 or 7, depending on the faculty) it is assumed that there are no drop outs; those leaving the last level are graduates.

Change of study is treated as follows. Repeaters on level 1 will either repeat their original study or begin at level 1 in a new study. Repeaters on higher levels will either repeat their original or later chosen study at the given level or they will begin a new study in which they are assumed to start at the repeating level.

The students who enroll at the University, but do not begin a study (choose a faculty), give rise to certain problems. First of all nobody can graduate from this group. It is assumed that no one can stay in the group for more than two years. Thus after one year the students will with a certain frequency choose a faculty, remain for one more year in the group or drop out. In the second year they will either choose a faculty or drop out.

The transition coefficients are estimated from available statistics on the student population and its distribution by year of matriculation. However the population contains students who matriculated more than 30 years ago. The estimates that are primarily based on the last 6 or 7 vintages are then corrected with the purpose to include all students in the population. These corrections are under the assumption that drop out and repeater rates are decreasing as the students move on to higher levels.

The transition coefficients used in the model result in the total graduation and drop out rates shown in Table IV. 6. 1. These rates fit very well with real life rates.

Table IV. 6. 1 - Graduation- and drop-out-rates

Faculty	Graduation-rate	Drop-out-rate
Philosophy	0. 40	0. 60
Medicine	0. 62	0. 38
Social Science	0. 65	0. 35
Theology	0. 65	0. 35
Natural Science	0. 53	0. 47
University total	0. 52	0. 48

The number of students in one faculty is then calculated as the sum of students on all levels in the faculty. The number of students at each level is equal to the number at the same level last year less the number of drop outs, but with the addition of the number of students moving from the level below, see Figure IV. 6. 2. It is assumed that the transition coefficients at each level are constant, which means that they are independent of what has happened in the past. A survivor and a repeater at the same level have the same probability to move on, repeat or drop out. It can be debated if such an assumption (Markov-chains) is reasonable or not, however it is a usable assumption as the available statistics do not make it possible to estimate more detailed transition coefficients.

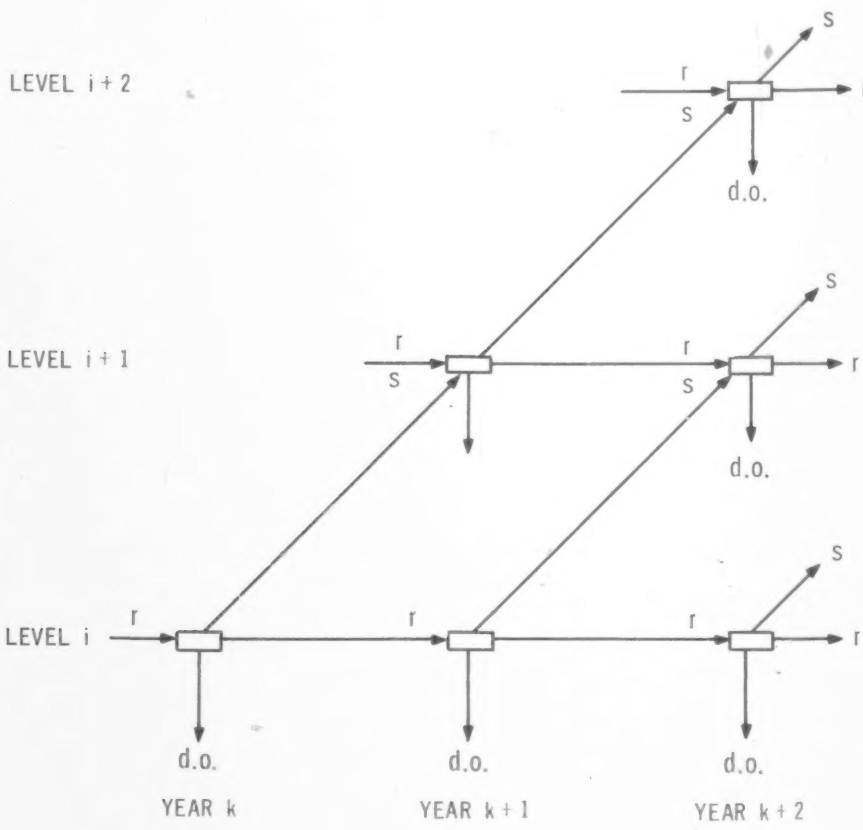
The model will calculate the distribution of the students on faculties and levels, the total student population in the faculties and at the University, the number of drop-outs and graduates. In Table IV. 6. 3 an example of the computer-output for the student flow model is shown.

Table IV. 6.4 shows the differences between the model and the actual, measured as a percentage of the actual (and official projections) data. Positive differences indicate that the model has an excess of students and negative differences indicate a deficit of students in the model compared with actual figures.

To a great extent the differences can be explained by the fact that the model does not take changes between faculties into computation. When this is taken into consideration the model's calculations seem acceptable. However it is not satisfactory that it is only possible to estimate the transition coefficients on a rather poor data basis. If the model shall have any chance to be used it is decisive that the statistics on the students are improved.

Figure IV.6.2.

PRINCIPLES IN CALCULATING THE STUDENT POPULATION


LEVEL i + 2
LEVEL i + 1
LEVEL i
r
s
d.o.
YEAR k
YEAR k + 1
YEAR k + 2

s: Survivers, moves on to the next level.
r: Repeaters, stay at the same level for another year.
d.o.: Drop-outs, leave the university.

Table IV. 6. 3 - The student-flow model, 1970

AAR 23 (= 1970)

AARG.	PHIL	MED	SOC	THEOL	NAT	SNS	TOTAL
1	2873	1031	1280	91	952	855	7082
2	2159	770	996	73	752	312	5062
3	1580	582	779	62	501	0	3504
4	1152	542	742	63	455	0	2954
5	829	531	724	58	408	0	2550
6	705	487	656	47	351	0	2246
7	0	458	0	0	284	0	742
BESTAND.	9298	4401	5177	394	3703	1167	24140
ENROLMENT.	1935	740	920	55	725	855	5230
DROPOUT.	877	212	249	17	268	435	2058
GRADUATE.	511	358	477	31	245	0	1622

Aar = year, Aarg = level, Bestand = population, Sns = subject (faculty not selected).

Table IV. 6. 4 - Differences between the model and real life data (Measured in percentages)

Percentages	Phil.	Med.	Soc. Science	Theol.	Nat. Science	Fac. not chosen	University
1965	- 6	- 6	- 2	- 18	1	37	- 3
1966	0	- 6	- 1	- 16	3	15	- 1
1967	- 6	- 7	- 4	- 18	2	18	- 4
1968	- 2	- 2	4	- 8	6	44	2
1969	- 3	0	5	- 2	9	77	3
1970	- 10	- 3	1	- 8	2	18	- 2
1971	- 12	- 3	0	- 7	2	18	- 3
1972	- 14	- 3	0	- 10	1	18	- 3
1973	- 14	- 3	0	- 10	1	19	- 3
1974	- 15	- 3	0	- 9	1	19	- 3
1975	- 15	- 3	0	- 9	1	19	- 3
Student population 1969	8893	4179	4673	393	3165	604	21907

b) On basis of the distribution of the student population calculated in the student-flow model it is possible to calculate the need for teaching, when class-sizes and number of hours per class are known. This is done in the next step of the overall model.

At each level we calculate the number of classes, and by multiplying this number with the number of hours per class per week we get an estimate of the total need for teaching.

By doing this we will observe that it is not always the fact that an increasing number of students leads to an increasing demand for teaching and vice versa. It will depend on the distribution of the students on levels and the combined effect of class-sizes and hours per class. At low levels we often observe relatively big class-sizes and many hours per class, at higher levels we often have individual instruction.

The data on class-sizes and hours per class used in this part of the model were given by the University's Data and Service Office.

c) The teaching capacity of the University depends on the number of teachers and their distribution among faculties. On the basis of student/teacher-ratios it is possible to calculate the number of teachers. With a given structure in teacher positions it is then possible to distribute the total number of teachers among professors, associate professors etc. Also when we know how many lectures a professor or a teaching assistant etc. is expected to supply (for instance per week) we can calculate the University and faculty teaching capacity.

This part of the model is set up in the three steps mentioned. This enables the University or the faculty to change the student/teacher ratio as well as the structure of the positions.

If a faculty experiences an under-capacity (excess demand for teaching), they can now for a given structure calculate how big the change in the student/teacher ratio has to be to meet the demand. They can then ask the Konsistorium for the additional number of positions. If it is not, or only partly, accepted, the faculty still has the possibility to meet (to a certain degree) the demand by changing the structure of the positions and to use more teachers with higher teaching obligations.

We distinguish between the following types of teachers : professors, associate professors and assistant professors (all tenures), lecturers and teaching-assistants (non-tenures). Tenure positions are included in the ceiling on positions which the Ministry of Education imposes on the University, while the non-tenure positions are outside, but the University must be able to pay them their salary. How the faculty chooses to meet the teaching demand depends on research too, and it can therefore not be expected to choose non-tenures alone. It will rather choose to let a tenure use a part of his research- "time" for teaching, by which it gets at least some research.

However the following figures show that one faculty has a rather large over-capacity, another almost a balanced capacity, leaving the three remaining with large under-capacity. For the University as a whole the under-capacity is only 7 %, indicating that the supply of hours is 7 % less than the demand.

Table IV. 6. 5 - Percentages of covered teaching-demand

Faculty	1968	1969	1970	1975
Philosophy	62	64	61	67
Medicine	90	92	96	99
Social Science	53	57	57	67
Theology	43	38	41	77
Natural Science	183	180	170	161
University	93	94	93	96

The percentages of covered teaching demand shown in Table IV. 6. 5 only partly give a picture of the real situation for the tenures. The non-tenure teachers who are paid to supply a certain number of hours have to be subtracted from the calculations : a teaching assistant who is paid for 4 hours per week will supply 4 hours. When the non-tenures are subtracted the remaining demand has to be met by the tenures. As the teacher/ student ratios in the faculties are very different and as the number of non-tenures too is very different, we come to the result that in 1969 an associate professor, who is expected to supply 4 hours a week, in the Philosophy Faculty has to supply 8 hours a week, where his collegue in the Natural Science Faculty only has to supply 1 hour.

The model enables the University to calculate figures like the ones mentioned above. When the differences are known to the Konsistorium, then it has to decide whether the differences shall remain unchanged or need to be levelled. This can be done by the allocation of new resources and/or reallocation of already allocated resources. However there are restrictions on how fast resources (here manpower) can be released from one place and moved to another. Point (e) in this section deals with this restriction. H. J. Rasmusen's allocation-model deals with the problem of the criteria to be used when reallocations are going to be made and it gives an example of a usable procedure (Chapter 7).

However the important thing here is the fact that use of the calculations in the model shows the consequences for the different faculties of alternative uses of resources and especially that already allocated resources have to be taken into account.

d) When the number of teachers, administrators, technical assistants, and lecturers is calculated we are able to work out the University budget. First of all it should be mentioned that according to the rules, all the wages and prices used in the budget are for 1st of April one year before the budget-year starts. Then we know exactly the wages which are going to be used in the budget for the different types of personnel. Further, we assume that each teacher in a tenure position has an overhead, depending on which faculty the teacher is engaged in, but independent of the type of teacher. This overhead, in principle, covers all running costs. The only exceptions are rents and taxes, which are considered as fixed costs.

Now it must be recalled that the University is subject to two limitations : a ceiling over the size of the budget and a ceiling over the number of tenure positions. The model is only able to calculate the budget on the basis of the calculated number of tenure positions, and we cannot be sure that the calculated budget respects the budget ceiling, even if the personnel ceiling is respected. This is caused first of all by the distribution of the personnel on the different types of positions (expensive or inexpensive positions), secondly by the distribution of the teacher positions on faculties, and of course a combined effect. The Konsistorium can then choose either to use more inexpensive personnel in general or to move teachers from the expensive faculties to the less expensive ones according to the criteria or objectives they have.

If the simulated budget, with a given structure in the positions and a given distribution of positions among faculties according to the criteria, does not respect the limitations of the actual, then the money will be a scarce resource.

If the opposite is the case, that the University cannot use all of the allocated money with a given ceiling on manpower, then the manpower is a scarce resource. If the Ministry of Education gets information on this it will be able to reallocate the resources between the different institutions so that at least some of the scarcities are levelled off against each other. To what degree this will be the case depends on how the Ministry acts and on whether it has an objective and the managerial capacity to act.

If we compare the University's budget estimates for the period 1971/72 to 1974/75 with the estimates in the model, we see that the manpower is the scarce resource.

An important observation in this part of the model is that the model shows that the Konsistorium, when it makes the budget first of all, ensures that all faculties have the same standard (student/teacher ratio and overhead per teacher) that they had the year before. Only to the extent that there are resources available do they try to better some ratios or increase some overheads. (It shall be remembered that ratios and structural parameters are based on information from the Budget Office at the University.) Such a policy can only work in a period with expansion, but if the growth rate of the budget and manpower ceilings level off, then serious trouble will arise if once allocated resources cannot be touched.

e) As mentioned earlier there are special restrictions on the use of manpower. The Ministry of Education tells the University that in the coming budget year it has at its disposal over 2787 positions. In the present budget-year the ceiling is 2707 positions. What consequences will an expansion of 80 positions have for the total teacher population ? It should be remembered that we just come out of a period with rapid growth so that the teacher population is heavy at the bottom with a large number of younger teachers. Further the large growth rate has resulted in a large promotion rate.

It should be emphasized that this part of the model at the present stage is only a calculated example due to the lack of data on the teachers. The parameters of this part of the model are not based on any information and are based on the authors'assumptions alone. However, we have tried to estimate the parameters as near to the real situations as possible.

First of all it is assumed that nobody can stay in the teacher population for more than 30 years. In each year the teachers are subject to a probability of leaving the population. This probability is the total effect of two single probabilities : (1) leaving by death and (2) leaving voluntarily (e.g. by getting a job outside the University). According to the value of the parameters used in the model the average expected lifetime is 22 years. This can be compared with Robert M. Oliver et. al. (1), where the average expected lifetime is assumed to be 25 years.

The model contains the three tenure-types of teachers - professors, associate professors and assistant professors. The number of each type is taken from the capacity part of the model. First of all it calculates the actual population one year ahead and it will of course loose some who leave the system either by death, voluntarily or by retiring. It then calculates the need for new professors and tries to recruit that number. Secondly it calculates the need for associate professors and tries to recruit that number too. The basis for recruitment is in both cases the assistant professors with 10 to 15 years seniority. If there is not a sufficient number of assistant professors to meet the demand then the model calculates the lack of professors and associate professors, in order to recruit a corresponding larger number of assistant professors, so that the total number of teachers needed would actually be present in the population.

If the opposite situation should appear, that the population in the previous year reduced by retirement and other resignations is bigger than the need this year, then the model will not recruit any new teachers. It will not however force anyone out, so in this case there could be more teachers than needed in the population.

In both cases the model will recalculate the budget too, so that it only contains the wages that are needed to pay the actual composition of the teaching staff.

If for a long period we have had rapid growth,the staff will have more assistant professors than actually foreseen by the structure. This can of course be avoided by recruiting professors from outside the University, but this possibility is not taken into account in the model. As time passes, we would there by get a broader basis for recruiting to the promotion-positions. The consequence will first be that an assistant professor has to stay a longer time as assistant professor, secondly he will observe an increasing risk of not being promoted. The result of such a development could easily be a change in the younger teachers' attitude towards a career at the University and thus change the parameters in the model and probably shorten the average expected lifetime.

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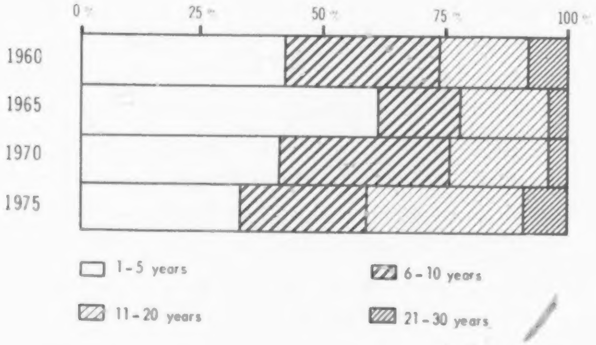
(1) Robert M. Oliver et. al., An Academic Productivity and Planning Model for a University Campus, Berkeley, Calif., February 1970.

Figure IV.6.6.

TEACHING-STAFF DISTRIBUTED BY YEARS OF SENIORITY



Seen from the University's point of view this will be a desirable development. The teaching-staff has to be distributed on faculties in accordance with a certain distribution of the students. A shorter average expected life time will make it easier for the University to make the necessary adjustments when the growth of the teaching staff is low, because the replacement demand will be bigger, the lower is the average expected life time. The decisive point here is that we, on the one hand, have a teaching staff with an average expected life-time of 22 years, and on the other hand, a student population with an average expected life time of approximately 4 years. Thus of course the distribution of the students on faculties will be able to change more rapidly than the teaching staff distribution.

In Figure IV. 6. 6. is shown the age distribution of the model's teaching staff. From this it can be seen that if the growth levels off completely, then the number of replacement positions, for a long period, will differ very much from year to year. Also this calls for an explicit manpower policy, i. e. that the University has to plan the establishment of new positions, and what is important at the present stage of development, that it has to take over all positions which are going to be replaced and evaluate if they should stay where they are or if there are places with more immediate need.

f) An evaluation of the model must consist of a discussion of the following parameters :

a) survival rates, repeater rates and drop-out rates ;
b) class-sizes, hours (lessons) per class ;
c) student/teacher-ratio, structure in teaching-staff (tenures), number of hours per teacher ;
d) wages, overheads ;
e) survival rates for tenures, procedure of promotion.

The most critical parameters in the model are those determining how the student passes the study. It is not possible to make a direct estimation because of the fact that statistics on students today only give a distribution of the students on faculty and year of matriculation. It has therefore been necessary to take as the starting point the surviral rates for each of the statistic vintages of newly enrolled students and on basis of this make the estimate of the transition coefficients of the system. A kind of guidance in making this estimate is given in the knowledge of the actual drop-out and graduation rates, which at least give the possibility of making reasonable estimates on the size of the repeater rates and on the level at which they are placed.

However, although we find that this way of doing things has resulted in reasonably good results, this part of the model is not yet satisfying. It is not possible to make any control of the distribution of the students on levels of study, which is important for the calculations of the teaching demands.

The transition coefficients belong to that set of parameters which are beyond control. They are a function of the other parameters of the model and we cannot predict their reaction to changes in other parameters. It is therefore important that these parameters be estimated with a high degree of certainty, so that we, in calculations of consequences of changes in other parameters, are not embarrassed by uncertainty in the parameters themselves as well as the uncertainty in their reaction.

Due to lack of data the class sizes and number of hours per class are also vitiated by a high degree of uncertainty. This uncertainty is however not as critical as in the case of the transition coefficients, because they are not used in any other part of the model. It will be remembered that the demand for teachers and other personnel is calculated on basis of the student/teacher ratio and the composition of the personnel. The total demand for teaching hours is only calculated to judge whether the working conditions for teachers as well as students are reasonable. If we look at the question from a purely budgetary point of view then the problem of demand for teaching hours would be non-existent : to respect the ceilings (money and man power) the University would plan the studies in such a way that they could be carried through with the given capacity.

Student/teacher ratios, structural parameters on the staff, number of hours per teacher, wages and overheads are on the other hand quite firm, primarily due to the work on statistics on students and budget matters, which is done in the Ministry of Education.

As far as the staff-flow-model is concerned it has the same weaknesses as the student-flow-model. The mortality can, however, be calculated with a high degree of certainty, but it is only correct if the assumption of a maximum of 30 years of employment is true. After all, this maximum is certainly a little too short and therefore the average expected lifetime will be too short and hence the replacements in the system will happen too quickly. When this is the case, some of the manpower problems mentioned above will be more difficult to handle in real life than estimated here.

A second qualification to the staff-flow-model is the assumption that assistant professors are only promoted in the period between 10 and 15 years of seniority. Regarding promotion to a professor position the assumption might be true, but as far as promotions to associate professor positions are concerned, they probably take place for younger assistant professors (rather than those with 10 or more years of seniority). The assumption is only justified by the fact that it facilitated the setting up of the computer-program which would have been difficult if different promotion procedures for professors and associate professors would have been assumed.

In the next section we shall deal with simulations. We will also discuss the uses of the model.

Simulations

A simulation model of the university can be used to calculate the consequences of different developments in the parameters. Further, if we are not able to set up a criteria that can be used in an optimization model, we can run a number of alternatives and then choose the most satisfactory one.

The model is set up using data available from the budget-estimates, comprising student/teacher-ratios, position-structure and overheads. For given transition coefficients these, together with the parameters determining the teaching demand, are decisive on the use of resources.

As mentioned in Part III the University now faces a period with very low growth-rates. It is therefore very important for the University to be aware of its own behavior. It will not be possible for the University to live only on the marginal additions, it has to review critically the total amount of resources already allocated. The use of a simulation model will enable consideration of the total allocation.

However, before using the simulation model we have to make sure that we have control over the parameters. If one or more parameters react to the change of another, in what direction and to what extent will there be a reaction ? If it is not possible to estimate the numerical values of these reactions then we have to simulate some alternative estimates, so at least we have a number of alternative consequences to a primary change in a parameter. By doing so we will be able to set the limits for the consequences (e.g. that a change in the structural parameters on positions will result in an average expected lifetime of between 18 and 20 years).

In discussing the problems of the teachers' survival it was argued that situations could arise where the position-structure and a very low promotion rate would cause reaction in the employees' attitudes and cause a higher proportion to retire voluntarily. Another example can be mentioned.

A lower student/teacher-ratio (standard-improvement) is often expected to increase the system's productivity (a higher graduation-rate). The purpose is then to influence the transition coefficients. It is however difficult to say anything a priori as to which of the three coefficients will be changed and to what degree. Further, in a situation with restrictions on the growth rate of manpower the University cannot carry out any improvements in efficiency, as these are dependent on whether the necessary manpower resources can be provided. It is uncertain what the consequence of an increased input of resources will be.

The conclusion is therefore pretty discouraging. We are in a situation where we can say nothing a priori, on the reactions, probably not even in what directions they go. A way out could be to postulate a reaction and then run the model for different alternatives, setting up some possible limits on the consequences.

In the following section we will discuss four different simulations, their consequences and their problems. It is here assumed that a simple simulation of the trend of development, which is built into the model as set up and discussed in the former section, does not cause any problems.

The first thing to be discussed is the consequences of a "relief", by which we understand an arrangement that reduces the expected new enrolment of students to one or more faculties. Such an arrangement will be decided outside the University and will appear as a general or specific regulation on enrolment or, e.g., as a construction of a competitive institution. The University must therefore be prepared to meet a decrease of its ceilings.

If the relief appears as restrictions on enrolment then we will assume that the number of applicants can be calculated quite exactly and then the new figures can be put into the model.

If it is the construction of a competitive institution then we can say nothing precisely on its influence on enrolment to the University. First of all there may be other institutions besides the University which must give up students to the new one. Secondly the construction of a new institution can lead to an increase in total enrolment. Therefore the relief on existing institutions need not necessarily match the capacity of the new one.

In Denmark, the construction of the fourth university has been started, which is situated in Roskilde, approximately 30 km from Copenhagen. It is proposed to start educations competitive with those in the Philosophy, the Social Science and the Natural Science Faculties at the University of Copenhagen, but also competitive with the educations at the School of Economics and Business Administration. It has been assumed that 50 % of the planned enrolment in Roskilde alternatively would have enrolled at the University of Copenhagen. Further it is assumed that the parameters for the three faculties shall remain unchanged. Then the model can calculate how many resources can be transferred from the budget estimates without decreasing the standards or in any other way interfering with the development aimed at.

In the actual case the simulations showed that the manpower ceiling of the University for 1972-73 could be diminished by 35 positions and the money ceiling by 4,3 million Danish Kroner compared with ceilings last year allocated for the budget-estimate period. Further, another consequence will be that the demand for new assistant professors will decrease and this will lead to quicker movement towards a more even distribution on age groups than the original demand.

A very important thing in a simulation model is the establishment of the parameters. To calculate the parameters on the teaching demand, we need a quantification of the study-plans. That is, they have to be transformed into class sizes and hours per class at each level defined in the plans. Changes in the plans can result in changes in the parameters.

The parameters used in the model are composed of a lot of individual parameters from each single study. If the model was set up at the faculty level, then it would contain all these individual parameters, and the total outcome of the model at this lower level determines the parameters used in the upper-level model. Therefore, we can say that the model records the net-effects of series of decisions made by study committees, boards of institutes etc. Within an appropriation system with ceilings this is, however, sufficient information for the decision-makers, who have to decide on the distribution of the resources. The Konsistorium only needs to have knowledge on the total load on the different faculties to make the necessary adjustments.

The load mentioned above is a teaching-load alone. However, research is not forgotten. When,on basis of the teaching-load, we calculate the number of teachers we take research into account in two ways : (1) the distribution of the teachers on tenures and non-tenures and (2) the use of non-scientific (technical) assistants.

If we reduce the class sizes the teaching-load will increase. The model will not automatically increase the number of positions so that the demand for teaching is covered by the supply. The first thing to do then is to evaluate if the following change in the teachers'teaching load is acceptable or not. Secondly we can calculate the number of teachers necessary to reduce the load to an acceptable level (the same as original). When this is done we must test if the ceilings on money and manpower are respected and - if not - make the necessary adjustments. If the manpower ceiling is the critical one we can first reduce the student/teacher ratio as much as possible and then change the non-tenure/tenure ratio in order to increase the number of non-tenures.

The actual (real life) ceilings (from the budget-estimates, November 1970) are however so narrow that only by changing the structure between the different tenure-positions (taking the whole increase in assistant professors,and saving some wage-expenditure compared with the original structure,and then using this to buy non-tenures) can we increase the teaching capacity by 1. 5 %. If the institute level and the faculty level should ask for bigger increases in the teaching capacity than 1. 5 %, then the Konsistorium has to answer that it is only possible to add 1. 5 % to the teaching capacity by implementing certain structural changes. However it is still possible to increase the capacity in certain areas by more than 1. 5 % and by less than 1. 5 % in other areas. To what degree will this be the case depends on the criteria used by the Konsistorium and secondly by the faculties.

The concept of standards at the University is ambiguous. By tradition, standards are often referred to as expenditures per student. An average expenditure can, however, cover a number of different structures in expenditure, which makes it possible to realize different teaching capacities. This is also true if we count standards as the number of teachers per student (or what is equivalent, the number of students per teacher). The possible capacity is then dependent on the distribution of the different kinds of teachers. However this problem could be solved by counting the teachers as full time-equivalent, but this will make it impossible to relate the concept of standards to the budget's concept of manpower. These difficulties are the reasons why the model operates with two kinds of parameters in this section of the model : one parameter representing the student/teacher -ratio and another representing the structural situation.

Another reason is to give the University a maximum of freedom of action. This has been tested in a simulation of reallocation of the resources allocated by the model's original parameters. A restriction on the possibilities of carrying out reallocations is the unwritten rule that resources once allocated cannot be touched, which means that if a faculty has 100 positions and 10 million Danish Kroner allocated in year 1, then this amount of resources will be the minimum in year 2. However, let us assume the Konsistorium,faced with smaller increases in marginal resources,agrees that reallocations compared with plans set up last year have to be accomplished. The Konsistorium can then decide on the highest acceptable student/teacher ratio for the faculty or the faculties that have to reduce their growth rate. The model will then calculate the length of time it will take to reach the new student/teacher - ratio respecting the above mentioned restriction, and secondly it will calculate the number of positions released. This is however done for a given structure on the teacher-positions. The faculty will still have the possibility to change the structure in order to diminish the relative decrease in capacity. The next step for the Konsistorium will be to decide on the distribution of the positions made available by the first step.

However the solution of the problem discussed here needs a number of successive adjustments and it could be rather a time consuming procedure. If the Konsistorium does not have an objective then this procedure is superior to the calculations made by hand that are used today. But, if there exist an objective then the simulation model can be used to calculate the restrictions (the minimum amount of resources allocated to each subunit) and the number of periods in which a reallocation can be carried out. Then an optimization model for given ceilings will give the solution very quickly (see Chapter 8 of the report).

In November 1969 the Ministry of Education set up a commission on the structure of academic positions in universities and other institutions of higher education. The commission comprised representatives from the Ministry of Education, the Ministry of Wages and Pensions, the Rektors and Administrators of institutions, the Civil Servants Union, the Union of University Educated Teachers and the students. The majority of the commission advocated a structure containing three types of tenures : professors, associate professors and assistant professors. Further a goal was set up that the institutions should have a ratio of one professor per three tenures. The report does not say anything about what level this ratio should be carried out on, and nothing definite is said on how long it is assumed to take to implement. However we assume that it would be at the faculty level.

In the case where the ratio non-professors/professors is higher than 2. 00 there is a shortage of professors. When the ratio is lower than 2. 00 there is a shortage of non-professors. The quickest way to realize the ratio will be to recruit professors or non-professors as the case may be. Anyhow, we must respect the ceilings in both cases.

If the ratio today is higher than 2. 00 we could, in principle, promote a sufficient number of non-professors to professors. However two problems arise. Firstly, it costs money, as professors are paid a higher salary than assistant and associate professors. Secondly a transfer of a number of teachers from a group with a higher teaching duty to another group with a lower teaching duty will reduce the total capacity. If this reduction is going to be met by the recruitment of a sufficient number of non-tenures then the whole procedure will be more expensive. The conclusion is then that it will only be possible to establish the desired ratio more rapidly than would result from natural development, by using the marginal budget - and personnel increases, if at the starting point there is room in the budget to pay what is really only higher average wages to the teachers.

If the ratio is lower than 2. 00 no one will be promoted to a professor until the ratio is established. The total marginal increase will be used for non-professors and future retiring professors will be replaced by non-professors. With the heavy restrictions on the manpower expansion which the University faces, it will not be possible to establish the ratio very rapidly. However, no one will expect the teachers themselves to be very eager to establish the ratio in this case and thereby reduce their own chance for promotion.

We have tried to let the model simulate the carrying out of the new structure respecting only the manpower ceiling. The only faculty that, in the period concerned, will be able to establish the ratio is the Philosophy Faculty, where it should be reached in 1978 (given an unchanged student/teacher ratio). As far as the Social Science Faculty is concerned the ratio today is approximately 1. 00, and given an unchanged student/teacher ratio, the ratio 2. 00 will be reached around 1995.

For the University as a whole it was calculated that total capacity was 1% lower compared with a situation with an unchanged personnel-structure and unchanged student/teacher ratio, while the expenditure per student is 1% higher. This needs to be taken into account when considering the implementation of the new structure. If it is desired to increase the professors' share of the total teacher-population, the consequence will be either that the budget has to be increased or the way of teaching has to be changed to reduce the demand for teaching hours.

The information system and the need for information

The preconditions for the implementation of the simulation model are (1) the fixing of which parameters are exogenous to the University and which are the University's parameters of action, (2) that the construction of the model is based upon a complete and detailed analysis of the structure which the model is supposed to describe, and (3) that the information system is adequately organized in order to ensure that continued use of the model.

The first thing mentioned above is the matter of the range of the freedom of action given to the decision level covered by the model. Parameters exogenous to the University represent restriction on the University (wages have to be paid by the University, but they are agreed upon between the Government and the teachers union). To this come other restrictions of absolute sizes such as the budget- and personnel ceilings. The wage parameter will therefore influence the way in which the University disposes within the personnel ceiling. In this way the parameter expressing the personnel structure is a parameter of action. - Other parameters are restrictions to one level, but parameters of action to another. For example class sizes and hours per class could be parameters of action for the institutes and study committees, but restrictions for the faculties, which then have to act on other parameters. However the opposite could be the case, that the faculty allocates a certain capacity to the institutes leaving them with the possibility of acting on class sizes, hours per class or both.

The second precondition can be expressed in the way that all parties concerned have to agree upon the parameters. The basis of the model was the student population and its distribution on study-levels. Therefore, it is necessary that a statistic on study-progress be established, which makes it possible to calculate the repeater and drop-out ratios and thereby the survival ratio as well. If anybody is able to contest the ratios used in the model, it can not be expected to be used. It needs to be emphasized that a statistic on study progress is not tied to a rigid and formalized study structure. It is sufficient that we are able to define a number of educational units (a vocational activity, a series of seminars, a course, a series of lessons of a certain duration of time). We can imagine that we can reach the same unit in different ways. Everybody participating in a certain unit need not be at the same point in their study progress. The statistic must be based upon individualized data to ensure that everybody is placed in accordance to their study progress up till now. Further it is necessary that up-to-date information is given on the activities, which are the contents of the above defined units. For a given student population and a certain activity we shall be able to calculate the necessary teacher hours, preferably in hours of different types of teachers. This, first of all, enables us to calculate the total demand for teachers and secondly the demand for different types of teachers. Further, we shall be able to estimate the consequences (economic) of substitution between the different kinds of teachers. There is, therefore, a need for information on class sizes and hours per class (per week, per semester or per year). As far as manpower is concerned we have to have knowledge on the personnel structure and on those duties which can be imposed on teachers as well as administrators and technical assistants. Related to the teachers there must be established a statistic similar to the statistic on study progress for the students. We have to know something on survival ratios, promotion possibilities and the existing structure in the scientific positions to be able to calculate the consequences of the implementation of a new structure and the consequences for the teaching staff of changes in the growth rate of the personnel ceiling.

The information system must be able to keep the statistic on study progress up-to-date as the number of students in the student population is dependent on the way and speed with which the students pass through the system. Further all changes in study plans must be registrated or otherwise it will not be possible to calculate the actual need for teachers and their teaching load (and hence their research possibilities) and the need for additional manpower. As wages and other prices are (assumed to be) fixed outside the University, we need a careful statistic on all kinds of materials and services consumed. Only by keeping a check on all expenditure can the University utilize all the advantages of the budget ceiling-system (see Part III, Chapters 4 and 5).

Finally we have to be aware of the data which are the bases for the estimates of the flow parameters, e. g. data on students' study progress and the recruiting and retiring of the staff. First of all these are the fundamental parameters of the model, secondly they can not be taken for granted in every situation. If we want to establish a new structure for the scientific personnel it is not certain that the survival ratio is independent of what is going to happen. For the sake of the University's ability to manage itself it is important that changes in the flow parameters are registrated as soon as possible so that the necessary adjustments in the model can be made.

However, are any possibilities available within the existing information system ? We have a Student-matrikel that identifies each individual student, but it cannot be used to place the students on any study level. An Examination's and Teaching's Administration is under construction. It is based upon information on educational activities, which demand a notification. The use of the Administration is only possible if it is previously supplied with information on class sizes, hours per class, rooms and teachers available and conditions for the passing of the examinations. However, if this information is given we have a quantified study plan and the beginning of the basis of a statistic on study progress. The Examination's and Teaching's Administration will contain information on which students are taught in what subject, where, when and by whom.

Further we have a Room-matrikel and an Institute-matrikel, which contain complete information on available rooms and the names of all individual institutes and other sub-units of the University. The Stabs-matrikel contains information on all employees at the University. It enables the University to calculate the teaching capacity totally as well as partially. Further we can check the personnel structure by using the Stabs-matrikel and we can obtain data on recruitment and retirement. Unfortunately, the Stabs-matrikel is not working very well for the moment. Finally we have the economic information collected for budgetary and accounting purposes.

As far as the question of a statistic on study progress is concerned it is not possible today to obtain one. However, a starting point could be the annual notifications supplemented with an explicit registration of changes of study. Further, the establishment would be possible if the Examinations and Teachings Administration registrated the individual activities' mutual relations and then registrated the students on that basis. What is decisive is that a statistic on study progress shall record the students in relation to their current and past activities (level of study) and not in relation to their year of matriculation. The construction of the Examinations and Teachings Administration is dependent on a quantification of the study plans, that is, that each subject be established as one or more activities accompanied by class sizes, hours per class and teaching staff. Moreover knowledge on the individual activity's relation to other activities is needed.

In principle, it should be possible to establish a statistic on the teachers' f[illegible] through the University, so that for instance the problems around the new structure of the teacher positions could be solved. However, as mentioned above the Stabs-matrikel is a weak point in the present system.

All the demands on the information system must be fulfilled at the same time, otherwise we cannot be sure that the model will give reliable results. A number of the necessary data are already gathered in the present system, but not prepared in a proper manner required by the model. These have to be changed and, further, the remaining information collected and prepared. There do not seem to be any technical problems to be overcome. The question seems merely to be whether the decision-making bodies at the University will involve themselves in decision-making, that is to formulate a policy on the basis of which they can set up criteria for their decision, e.g. on resource allocation.

Mathematical structure of the model

Student flow and student population :

The indices :

i = levels of study ($i = 1, 7$)

j = faculties (j = 1 : Philosophy, 2 : Medicine, 3 : Social Science, 4 : Theology, 5 : Natural Science, 6 : Study not selected, 7 : University as a total).

k = year ($k = 1. 31$ (year 1 = 1948))

The variables :

IA (i, j) = survival rate (estimated, outside university control)

IB (i, j) = repeater rate (estimated, outside university control)

IC (i, j) = drop-out rate (estimated, outside university control)

ENROL (j, k) = new enrolment in faculty j, year k (outside control)

ST (i, j,k) = number of students at level i, faculty j and year k (endogen)

SST (j, k) = total number of students in faculty j, year k (endogen)

DROP (j, k) = total number of drop-outs in faculty j, year k (endogen)

GRAD (j, k) = total number of graduates in faculty j, year k (endogen)

The work with the model is initiated by setting

(1) $ST(1, j, 1) = ENROL(j, 1)$ for $j = 1, 6$

Then

(2. 1) $ST(1, 6, k) = ENROL(6, k)$ for $k = 2, 31$

(2. 2) $ST(2, 6, k) = IA(2, 6) \times ST(1, 6, k-1)$ for $k = 2, 31$

Next we can calculate

(3. 1) $ST(1,j,k) = ENROL(j,k) + [IB(i,j) \times ST(1,j,k-1)] + [F \times (ST(1,6,k-1) + ST(2,6,k-1)]$ for $j = 1, 5$ and $k = 2, 31$

and then

(3. 2) $ST(i,j,k) = [IA(i,j) \times ST(i-1,j,k-1)] + [IB(i,j) \times ST(i,j,k-1)]$ for $i = 2, 7$, $j = 1, 5$ and $k = 2, 31$

In (3. 1) F is a factor giving the proportion of students in the "faculty" not selected who after one or two years in that "faculty" choose a real faculty.

(3. 1) and (3. 2) give the number of students at each level in each faculty in all the years concerned.

(3. 3) $ST(i, 7, k) = \sum_{j} ST(i, j, k)$ for $j = 1, 6$, giving the total number of students at each level

(4) SST (j, k) $= \sum_{i}$ ST (i, j, k) for i = 1, 7, giving the total number of students per faculty (j = 1, 7)

(5. 1) DROP (j, k) $= \sum_{i}$ IC (i, j) x ST (i, j, k) for i = 1, 7 giving the total number of drop-outs in each faculty (j = 1, 6)

(5. 2) DROP (7, k) $= \sum_{j}$ DROP (j, k) for j = 1, 6 giving the total number of drop-outs at the University

(6. 1) GRAD (j, k) = $[1 - \mathrm{IB}(i, j)]$ x ST(i, j, k-1) for j = 1, 6 and i = 6 for j = 1 and 3, i = 7 for j = 2 and 4, 6, giving the total number of graduates in each faculty

(6. 2) GRAD (7, k) $= \sum_{j}$ GRAD (j, k) for j = 1, 6 total number of graduates at the University.

Demand for teaching

The indices are the same as above. The variables are :

HOLD (i, j) = class sizes at level i, faculty j (within control)

LESSON (i, j) = hours per class at level i, faculty j (within control)

HOUR (i, j, k) = number of scheduled hours per week, per level, within faculty j, year k (endogen)

SHOUR (j, k) = total number of scheduled hours per week at faculty j, year k (endogen)

The calculations are :

(7) HOUR (i, j, k) = LESSON (i, j) x $[$ST (i, j, k) / HOLD (i, j)$]$

(8) SHOUR (j, k) $= \sum_{i}$ HOUR (i, j, k) for i = 1, 7.

Teaching capacity

The indices :

m = personnel categories (m = 1, 6)

j and k as above

Variables :

RELAT (m, j, k) for m = 1 : number of students per professor
m = 2, 5 : number of non-professors per professor
m = 6 : number of technical assistants per teacher (tenure) (within control)

PERSON (m, j, k) = number of employed in category m, faculty j, year k (endogen)

TIMCAP (j, k) = teaching capacity measured as number of scheduled hours per week (endogen)

FORH (n,j, k) = student/teacher ratio, n = 1 : tenures, n = 2 : non-tenures (endogen)

The calculations are :

(9. 1) PERSON (l, j, k) = SST (j, k)/RELAT(l, j, k) giving the number of professors

(9. 2) PERSON (m, j, k) = RELAT (m, j, k) x PERSON (l, j, k) for m = 2, 5 giving the number of associate professors (2), assistant professors (3), lecturers (4) and teaching assistants (5)

(9. 3) PERSON (7, j, k) = $\sum_m$PERSON (m, j, k) for m = 1, 3 giving the number for teachers (tenures)

(9. 4) PERSON (6, j, k) = RELAT (6, j, k) x PERSON (7, j, k) giving the number of technical assistants

(10) TIMCAP (j, k) = $\sum_m$M(m) x PERSON (m, j, k) for m = 1, 5 and M(m) is the number of compulsory teaching hours per teacher in category m.

(11. 1) FORH (l, j, k) = SST (j, k)/PERSON (7, j, k) giving the number of students per tenure

(11. 2) FORH (2, j, k) = SST (j, k)/$\sum_m$PERSON (m, j, k) for m = 4, 5 giving the number of students per non-tenure.

University-Budget

The indices :

ma = types of wages and overheads, ma = 1, 8

j and k as above.

The variables :

WAGES (ma, j), ma = 1, 6 wages to corresponding manpower groups (outside control)

ma = 7 overhead to tenure-teachers (within control)

BUDGET(ma, j, k) = total expenditure (wages and overheads) on each category of personnel in each faculty (j) and in each year (k) (endogen)

UDGIFT (j, k) = expenditure per student (endogen)

The calculations :

(12. 1) BUDGET (ma, j, k)= WAGES (ma, j) x PERSON (m, j, k) for ma = 1, 7 gives

the wages and overheads in faculty j, year k

(12.2) BUDGET (8, j, k) $= \sum_{ma}$ BUDGET(ma, j, k) for ma = 1, 7 giving the total expenditure in each faculty, each year

(13) UDGIFT (j, k) = BUDGET (8, j, k)/SST(j, k), expenditure per student

Recruitment of teachers, teacher-flows, -population, budgetary effects

The indices :

ia = seniority, ia = 1, 30
ja = category of teacher, ja = 1 : assistant professor,
2 : associate professor,
3 : professor.
k as above.

Variables :

OVERL (ia) = survival-ratio at the ia'th level of seniority (outside control)
L (ia, ja, k) = number of teachers in category ja with seniority ia in year k (endogen)
SL(ja, k) = total number of teachers in category ja in year k (endogen)
SSL (k) = total number of teachers year k (endogen)
ANDEL (k) = ratio between the number of newly recruited teachers in year k and the number of graduates in year k -1 (endogen)
AVAGE (k) = average seniority (endogen)
MANKO 2 (k) and MANKO 3 (k) = difference between the need for professors and associate professors and the possible numbers.

The relation to the rest of the model is established through :

(14.1) SL (1, k) = PERSON (3, 7, k)
(14.2) SL (2, k) = PERSON (2, 7, k)
(14.3) SL (3, k) = PERSON (1, 7, k)
(14.4) SSL (k) = PERSON (7, 7, k)

In year 1 we have assumed that there was an equal distribution of the teachers on seniority. Then, the flow model can be initiated as follows :

(15) L (ia, ja, k) = OVERL (ia-1) x L (ia-1, ja, k-1)

Promotion procedure : Professors and associate professors are recruited among the assistant professors with 10-15 years of seniority. The recruitment is supposed to start with the older ones and the older are preferred younger. If the total number of assistant professors with 10-15 years of seniority is not sufficient to match the need for new professors and associate professors, then the model will recruit an additional number of assistant professors so that the demanded SSL(k) is reached.

The promotion procedure is then started for ia = 16 :

(16) $L(ia, ja, k) = SL(ja, k) - \sum_{ia} L(ia, ja, k)$ for ia = 1, 30 and ja = 2, 3

If

(17. 1) $L(ia, 3, k) \leq OVERL(ia-1) \times L(ia-1, 1, k-1) + OVERL(ia-1) \times L(ia-1, 3, k-1)$

then (16) is valid for ja = 3, and if

(17. 2) $L(ia, 2, k) \leq \sum_{ja} OVERL(ia-1) \times L(ia-1, ja, k-1)$ for ja = 1, 3

then (16) is valid for ja = 2 too. Then will

(18) $L(ia, 1, k) = \left[\sum_{ja=1,3} (OVERL(ia-1) \times L(ia-1, ja, k-1) \right] - \sum_{ja=2,3} L(ia, ja, k)$

also be valid .

If (17. 1-2) is not fulfilled then

(19. 1) $L(ia, 3, k) = OVERL(ia-1) \times L(ia-1, 1, k-1) + OVERL(ia-1) \times L(ia-1, 3, k-1)$

(19. 2) $L(ia, 2, k) = OVERL(ia-1) \times L(ia-1, 2, k-1)$

(19. 3) $L(ia, 1, k) = 0$.

Then we can calculate equation (16) for ia = ia-1 = 15 (and if necessary ia → 11) and for j = 2, 3. The conditions in (17. 1-2) are tested once more.

If (17. 1) is fulfilled, then

(19. 21) $L(ia, 2, k) = \left[\sum_{ja} OVERL(ia-1) \times L(ia-1, ja, k-1) \right] - L(ia, 3, k)$ for ja = 1, 3

(19. 31) $L(ia, 1, k) = 0$

and we calculate (16) for ja = 2. Finally we test (17. 1-2) once more.

(20. 1) $MANKO\ 2(k) = SL(2, k) - \sum_{ia} L(ia, 2, k)$ for ia = 1, 30

(20. 2) $MANKO\ 3(k) = SL(3, k) - \sum_{ia} L(ia, 3, k)$ for ia = 1, 30

If (20. 1) and (20. 2) equal 0, then is (17. 1) as well as (17. 2) fulfilled. If only (20. 2) is 0, then only (17. 1) is fulfilled (and vice versa). If (20. 1) as well as (20. 2) are positive then none of the conditions are fulfilled (and we cannot fill all the promotion positions).

After calculating the number who can be promoted to professors and associate professors, we can then calculate the total need for assistant professors :

(21) $L(1, 1, k) = SL(1, k) - \sum_{ia} L(ia, 1, k) + MANKO\ 2(k) + MANKO\ 3(k)$
for ia = 2, 30

(22) $ANDEL(k) = L(1, 1, k)/GRAD(7, k-1)$

(23) $AVAGE(k) = \left[\sum_{ja}\sum_{ia} L(ia, ja, k)\right] / SSL(k)$ for ja = 1, 3 and ia = 1, 30

In the situations where there is no agreement between the number of teachers, in the different categories, which the model will engage or promote and the number which is possible - according to the teacher flow model - to engage or promote, then the model will calculate a budget adjusted for differences in wages etc. Similarly it calculates a new corresponding expenditure per student.

Outline of the mathematical structure

Student population

The total student population in a faculty is :

$$S_{j,k} = \sum_{i} S_{i,j,k-1} + E_{j,k} - D_{j,k} - G_{j,k}$$

where S = Student population
E = New enrolment
D = Drop-outs
G = Graduates

i = studylevel i = 1, N
j = faculty
k = time

Demand for teaching

The total demand for teaching in a faculty :

$$N_{j,k} = \sum_{i} (S_{i,j,k} * H_{i,j} * 1/C_{i,j})$$

where N = demand (need) for teaching
H = number of hours per class, level and faculty
C = class sizes per level and faculty

Demand for positions and money

$$P_{m,j,k} = S_{j,k} * R_{m,j}$$

m = type of position

where P = number of positions per type and faculty
R = position / student ratio per faculty (incl. technical assistants).

$$T_{j,k} = \sum_{m} P_{m,j,k} (W_{m} + O_{m,j})$$

where T = total costs

W = wages per position (type)

O = overhead per position and faculty

Recruitment of new teachers

$V_{m, j, k} = P_{m, j, k} - P_{m, j, k-1} - B_{m, j, k} \qquad V_{m, j, k} \geqslant 0$

where V = net recuitment of teachers

B = retirement by death, age, promotion or voluntarily

In the lowest category of positions the recruitment takes place by new enrolment, in the upper categories we have promotions from a lower category.

Teaching capacity

$M_{j, k} = \sum_{m} (P_{m, j, k} * F_{m})$

where M = teaching capacity (measured in hours)

F = standard number of teaching hours for teachers in category m.

Chapter 7

DECENTRALIZED PLANNING IN A UNIVERSITY SYSTEM

by

Hans Jørgen Rasmusen

The planning procedure developed here operates in a decentralized manner, thereby reducing the central demand for data and activity statistics and permitting the faculties of the university a wide range of latitude in using the operation ceilings.

The planning procedure has been designed around the same kind of data as that used in the forecast-type model described by Niels Hammer-Jespersen. All teaching demands are in fact supplied by the forecast model. (Chapter 6).

This chapter is divided into two main parts. The first part is initiated by a discussion of the decision level at which the model is to be implemented. It continues with some notes on centralization versus decentralization, and it ends with a discussion on how a decentralized planning procedure under central control can be developed and how data can be obtained.

The second part is initiated by a discussion accompanying the use of a mathematical model. The constraint equations and the objective function is explained, and it is shown how a linear programming problem can be formulated.

The second part continues with an elaboration on the results obtained by using the model, as well as an explanation of the use of shadow prices and sensitivity analysis.

Finally we discuss how the model can be implemented and how the planning results can be applied in the planning negotiations, upwards as well as downwards in the system.

The level of implementation of the model

The model is developed to supply the top decision-making body, the Konsistorium in the University of Copenhagen, with the information necessary to provide a tool for the overall control of the university, as well as to supply the quantitative information required in the budgeting negotiations with the Ministry of Education.

Table IV. 7. 1. lists the computed weekly teaching capacity in the fiscal year 1968/69, and the computed weekly teaching demand for the fiscal year 1968/69, and the expected teaching demand in the future 4 fiscal years. The forecasts are all obtained from the forecast model developed by Niels Hammer-Jespersen.

Table IV. 7. 1 - Weekly teaching capacity/demand (hours) for the fiscal years 1968/69 - 1973/74

Faculty	Current capacity	Computed demand				
	1968/69	1968/69	1969/70	1970/71	1971/72	1972/73
Phil.	2812	4515	4847	5285	5602	6040
Med.	2242	2503	2648	2691	2836	2981
Soc.	876	1638	1692	1774	1884	1960
Theol.	84	195	224	224	166	166
Nat.	4544	2484	2670	3044	3110	3394
Total	10558	11335	12081	13018	13598	14541

Abbreviations : Phil. = Philosophy - Med. = Medical School - Soc. = Social Science - Theol. = Theology - Nat. = Natural Science.

From Table IV. 7. 1. we learn that the current total undercapacity amounts to approximately 7% in the basic fiscal year 1968/69. It is however more interesting when we learn that there is a highly unequal distribution of the available capacity and hence of the current resource allocation.

The five main faculties of which the University of Copenhagen is composed are virtually independent in terms of teaching obligations ; thus changing or implementing new curriculaes in one faculty does not (in the short run) change the teaching demand in the remaining faculties.

This independence does make it possible to develop accurate short-run forecasts of teaching demands. It is therefore possible to develop a planning tool which can allocate the available resources in a way best satisfying the anticipated future demands. The application of a decision procedure based on the future expected performance is however not easily done inside the faculties, because the continuous alterations in the course choices of the students render it literally impossible to forecast anything like the expected teaching demands for all different possible courses.

Although the current model does operate with five sectors, this is more a convenience in gathering data, and in tradition, than a methodological requirement. It is however very likely that the number of sectors should be increased to 10 or 15, thereby reflecting the number of main fields of study. Within the Faculty of Social Sciences, for example, the main fields are the Law School, the School of Economics and the School of Sociology, which operate practically independently of each other. The number of sectors is on the one hand determined by the number of activities which the central decision-maker considers it necessary to distinguish between, and on the other hand by the numbers which can be dealt with in the administrative procedures.

Centralization versus decentralization

Centralization is considered advantageous in situations where the objectives are only vaguely defined. By centralizing it is believed to be possible to supervise the total system and in due course to make the right decision. Unfortunately, centralized systems have never been able to work efficiently ; first of all because of the number of decisions to be made are enormous even in small systems, thus leading to a large pile-up of waiting cases. Secondly, large centralized systems are unable to work because the central decision-maker can never obtain the same information, or even digest the information, which is available in the various sub-units. Centralized decision-makers had tried to get around this trouble by establishing databases and information systems. Neither databases nor informations systems are however going to solve any of the planning problems. They might be very helpful devices, but they do not secure either a feasible solution or any guidance when more than one feasible solution exists. Furthermore the central decision maker will almost always be troubled by tendentious or biased plans, which he seldom has sufficient knowledge to counter-bias(1).

Decentralization on the other hand has many advantages. Much less information needs to be transmitted between the various levels, because the system permits its members to make decisions independently of each other. It is further possible to use the individual sector's special knowledge on its fields far more than it is possible in the centralized system. This issue is one of the strongest advocates for decentralization, and it is one of the arguments that most frequently have been used against any attempt to introduce management techniques, because these techniques often are assumed to go hand in hand with centralization.

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(1) Cyert, Richard M., March, James G., A Behavioral Theory of the Firm, Prentice-Hall Inc. New Jersey 1963.

The main disadvantages of uncontrolled decentralization are that plans selected by the individual sectors may be very badly balanced and seldom match the goals of the total system. Although inventory management is an essential part of a wholesale company's policies, it is usually not the inventory manager, nor the manager of any other department who sets the goals for the company. The same situation holds true in the university. Although it admittedly is the faculty members of the institutes who are the only persons who can understand the problem within their area, they are seldom competent to value the activities of other institutes or departments.

The University of Copenhagen, which has been studied in our case, is organized in a partly centralized and partly decentralized way. Some kinds of decisions are highly centralized, such as the annual marginal resource allocations.

All educational decisions are on the other hand highly decentralized. In fact the University administration often claims that it knows very little about what is going on in certain parts of the University.

However, although the budgetary allocations are centralized, two faculties, the Natural Science and to some extent the Medical Science, have been able to expand, leaving the three remaining faculties heavily undersupplied. It has been possible to reach this state of affairs because the two mentioned faculties always have prepared their proposals in a very careful and well-written form.

At the same time the central decision making body of the University has only considered marginal allocation and never attempted to consider whether or not the total resources in the faculties balanced the demands, thereby not preventing the imbalance of the resource distribution.

Decentralization with central control

Both the centralized and the decentralized systems have their advantages and it is possible to establish management systems which to a large extent bring these together. This procedure may be called decentralization with central control (1)(2). Sometimes this procedure unfortunately is referred to only as decentralization. The main idea is that the central decision-maker sets the objectives and to some extent the means by which they are to be pursued. The central decision-maker also distributes the scarce resources. However, in doing so, he only observes to what extent the sectors are able to fulfil his overall objectives. In other words he divides the resources according to the principle of equalization of marginal utilities among all sectors in accordance with his objective function.

There is however at least one requirement which must be satisfied in order to control the system this way, that is, the central decision-maker must trust the sectional decision-makers' willingness to try to satisfy his goals and not their own. If this is not possible, the central decision-maker must at least be able to counter-bias the information he receives from the decentralized sectors.

Decentralized systems might be kept under control in two different ways :

1) Price control (internal pricing).
2) Quota control (resource ceilings).

Price control or internal pricing has often been suggested as a means to control decentralized units. When the cost assigned to a specific commodity is increased, the amount used is decreasing, and at a certain value of the cost, the demand equals the supply.

The concept of internal pricing, however, seems to be difficult to comprehend for planning people, especially when they are trained in budgeting or accounting. The difficulty is due to the fact that people not very familiar with modern planning techniques find it hard to understand that a scarce resource is priced higher inside a system than outside. Several writers have reported the problems encountered in introducing an internal pricing system into the budgetary planning (3). Internal pricing has on the other hand been used very successfully in investment planning, possibly because it is another kind of people who apply the technique.

Quota control is another way of controlling the consumption of decentralized units. In this case the central decision-maker allocates quotas of scarce resources to the decentralized units, and he registers what they are able to do with allocated amounts.

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(1) Kornai, "Mathematical Planning of Structional Decisions", North Holland Publishing Co., Amsterdam, 1967. In a collection : Contributions to Economic Analysis, N° 45.

(2) Sengupta, J.K. and Fox, K., Optimization Techniques in Quantitative Economic Models, North Holland Publishing Co., 1969.

(3) Sewell, Wade P., "Internal Pricing for Air Transport Fleets," in Operations Research and the Social Sciences, Tavistock, 1966.

It is generally impossible to specify initially either the internal price or the quota allocation, which leads to an optimal solution for the total system. Both methods lead to the same optimal solution, and they are dual solutions to the same problem.

Speaking in terms of linear programming, decentralization controlled by internal prices is most frequently referred to as the Dantzig-Wolfe decomposition procedure, whereas quota controlled decentralization frequently is referred to as the Kornai-Liptak decomposition technique.

Quota controlled decentralization has many similarities to the way in which operating budgets presently are prepared, and we expect the concepts to be much easier to comprehend for the budgeting staff of a university, at least in the early phases of implementation.

The degree of decentralization

An inherent feature of the use of a decentralized resource allocation procedure is that only key data elements are transmitted between the two levels involved in the decision process. Depending on the number and content of the decision variables used in the model, more or less freedom and slack is available for the lower of the two decision levels. With few and highly aggregated variables the freedom is larger.

When the freedom to spend the resources is large, it becomes very likely that the resources are spent in ways which are incongruent with the goals of the total organization.

Ideally decentralized control should be exerted in a way which would minimize the inconvenience of the goal displacement. However the possibility of biasing the information transmitted between the two levels may render the control procedure very complicated(1).

This model is designed around the teaching demands and supplies, thus it is very tempting for the faculties to overestimate the teaching demands in order to obtain more resources. Clearly a control procedure must be developed, permitting a comparison between the expected demands and the actual achievements, thereby permitting a counter-biasing of estimates before they are used in the evaluation of plans.

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(1) Waks, N., Top management decision-making in large organizations, MITRE CORP, Mass. U.S.A., 1970.

The reason why the faculties want to overestimate teaching demands is that the members of the faculties usually have very pronounced research objectives. Even though the research activities do not appear as explicit decision variables in this model, this by no means indicates that research work is not appreciated by the central decision-maker. In fact we assume that the faculty members on the average use 50 % of their working time on research work. We have also assumed that research budgets and other operation budgets are merged together into general overhead accounts, with one overhead account for each sector. The most pronounced result of this policy is that faculty members are given an ultimate degree of freedom and latitude in the selection of research projects.

The decision variables used in this model are congruent with those used by the Ministry of Education, that is, manpower positions and money. These variables represent the resources made available to the University for operating purposes.

The University is divided into a number of sectors, which are treated independently, only linked together through the common resource ceilings. The resources are allocated to each sector (here faculty) in terms of ceilings, which the faculties use according to their usual standards.

Manpower and money are traditionally used in very different ways within each of the five faculties. Each faculty has developed its own academic grade structure. Furthermore ratios of teachers to secretaries and technicians are very different, the research and operations overheads are very different, and finally each faculty has adopted different policies towards the use of non-tenure teachers.

These differences must clearly be reflected in the planning model. Although not all differences are due to desired states, they are at least initial conditions. However one key feature of the decentralization is that the sectors independently may suggest and negotiate changes in these technical coefficients with the central decision-maker as part of the planning process.

From the distribution of manpower positions upon different teacher and non-teacher grades it is possible to compute the average "productivity" per position for the five faculties, when the average weekly teaching hours for each teacher grade is known.

In the basic fiscal year 1968/69 the Theology Faculty as an example had

11 full professors	at 2 weekly teaching hours [1]
1 associate professor	- 4 - - -
9 assistant professors	- 6 - - -
4 secretaries	

Totally they had 25 tenure positions available. The resulting average productivity becomes :

$$AP = \frac{2x11 + 4x1 + 6x9 + 0x4}{25}$$

$$= 3.20 \text{ weekly teaching hour/position.}$$

The average cost per position is computed in a similar way.

Two kinds of non-tenure teachers are available, both supplying 4 weekly teaching hours, however at a different cost.

Lecturers cost approximately Danish Kroner	22,000	annually
teaching assistants - - -	16,000	-

The cost difference reflects a different level of teaching experience.

The composition of non-tenure teachers is different in the various faculties, thus leading to a different productivity per unit of payment.

Table IV. 7. 2. summarizes the different measures of productivity and the incurred average cost including research and operation overheads for the tenure faculty members.

Obviously, less aggregate decision variables can be used in a planning model. It is indeed tempting to introduce for instance the research overheads and the number of secretaries and technicians as independent decision variables.

In order to do so, it is however necessary to make these variables appear in one way or other in the objective function of the model, because a model aimed towards the fulfilment of teaching demands gains no benefit from the introduction of costly variables, which do not - in the short run - contribute to the objective function.

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(1) These ratings assume that all types of teachers teach equally effectively. If this condition can not be satisfied, the ratings can be modified accordingly.

Table IV. 7. 2 - Summary of unit costs and productivity used in the model

Faculty	Average weekly teaching hours per tenure position	Average annual cost for 4 hours weekly teaching assistant Danish Kroner	Average cost per tenure position Danish Kroner
Philosophy	4. 38	17. 710	91. 890
Medicine	2. 07	22. 000	86. 807
Social Science	2. 66	18. 230	118. 152
Theology	3. 20	22. 000	111. 840
Natural Science	2. 54	17. 880	101. 182

Some readers might feel that the use of the decentralization concept is quite tendentious, because at the end we turn up with a centrally solved model. The explanation is that we do not expect this planning model to be the only one in use in the system. Each sector of the University may or may not choose to develop its own models.

In any case however the Konsistorium needs a way to estimate a reasonably accurate first allocation of resources so that a rapid convergence can be secured. The central decision-maker is not assumed to be able to interfere directly in what the faculties are doing or the way they are doing it.

A Mathematical Model

In order to solve some of the planning problems, we have tried to apply some recent developments within the planning area, especially the ideas in the Kornai-Liptak approach. The main emphasis of the mathematical planning procedure is not only on solving the allocation problems, but just as much on showing the decision-maker the kind of useful information he might obtain by using a mathematical programming technique.

The planning problem is attacked from a total budgeting point of view, that is, all available resources and all expected activities are analyzed at the same time. This procedure is considered superior to the current marginal budgeting procedure in which only new projects and new resources appear.

The total budgeting approach is a necessary part of a decentralized planning system, because the central decision-maker must be assured that the decentral leaders consider all their activities when planning, and to give them an incentive to terminate obsolete activities. A total budgeting approach is also required in order to secure that all liquid resources continuously are allocated in ways congruent with the over-all objectives of the organization.

An important feature is the possibility of measuring how resource demands from one sector, if fulfilled, impair the level of activity in the remaining sectors.

A mathematical model is a set of equations explaining the behavior of the system. In this model the equations have the form of a set of constraints, which specify the limits within which the solution must be located. The size and the shape of this solution space does frequently have a form permitting an infinite number of solutions or plans to satisfy the constraints.

It is however also possible that the constraints are so defined that no solution can satisfy all constraints simultaneously. When more than one solution exists to the planning problem, the mathematical model is of little value, unless it is able to select one or a small set of particularly good solutions. This feature is obtained by the addition of an objective function to the model. The objective function is also a mathematical equation, designed in a way expressing the major goals of the decision-maker.

The resource allocation model to be described is designed to cover all four years in the current rolling-four-year budgets. The University is decomposed into five faculties, which are treated as independent units. The faculties are linked together by a set of common constraints, reflecting the fact that at the next decision level the University is treated as an entity, where only total achievements and total resources count.

The means by which the central decision-maker can control the solution is through the allocation of scarce resources. Money and manpower positions are currently considered scarce resources. Money is fairly obvious. Manpower constraints, however, are introduced because the government has enforced limitations on the number of people who each year can be hired in public positions. All positions with a permanent tenure character are covered by the manpower ceilings, but people with a looser connection, as for instance teaching assistants, paid on an hourly basis, are not covered.

The physical facilities are not listed as scarce resources today, mainly because of a fundamental lack of data ; nor is the planning of buildings and other facilities included in this model, mainly because this today is administrated through other channels, and because we want to take one step at a time and want to see how simple procedures are understood before we embark on more versatile models.

The problem is formulated as a linear programming problem. Linear programming is by no means a satisfactory procedure ; it is however one of the most versatile computational systems presently available.

Constraint equations

1. The teaching equation

The teaching equation is a balance equation. Each faculty has one equation for each time period. The teaching equation says that the teaching capacity supplied by each manpower position plus the capacity supplied by each non-tenure teacher plus the slack must equal the teaching demand.

In mathematical terms we obtain the following equation using data from Tables IV.7.1. and IV. 7. 2. for the Philosophy Faculty year 1. (1969/70).

4.38*(number of tenure positions) + 4.0* non-tenure teacher + demand slack = 4847

The demand slack expresses the unfilled demand, thus, when the slack is zero, demand and supply equals. A positive slack means that the teaching capacity is insufficient. Negative slack cannot exist, because the linear programming technique does not allow negative variables. If overcapacity may occur, another slack variable is introduced to take care of the possible overcapacity.

2. The cost equation

The cost equation keeps track of the cost of running each faculty. The total operation cost of all faculties must each year be less than or equal to the total budget.

Again using the data from Table IV. 7. 2. and Philosophy Faculty we obtain,

91.890* (number of tenure positions) + 17.710* (number of non-tenure teachers) $\leqslant$ Budget of the Philosophy Faculty.

A similar equation is used for each of the remaining four faculties, hence the total cost equation becomes

Phil. costs + Med. costs + Soc. costs + Nat. costs + Theo. costs $\leqslant$ total budget.

3. The tenure position equation

This equation says that the total use of permanent (tenure) manpower positions within the University must be less than or equal to the manpower ceiling.

Phil. TP + Med. TP + Soc. TP + Theo. TP + Nat. TP $\leq$ manpower ceiling.

Since the model does not divide the tenure manpower into any subunit, no equation has to be defined for each faculty and the tenure position equation becomes a global constraint equation.

4. The teaching structure equation

This equation is a particularly important equation, because it controls the extent to which tenure and non-tenure teachers can substitute each other. In this model we have assumed non-tenure teachers to supply less than or equal to half the teaching demand.

In case of the Philosophy Faculty the equation year 1 becomes

4* (number of non-tenure teachers) $\leq$ 2423 weekly hours.

In the Natural Science Faculty the initial conditions show an excess supply of teachers, thus a slack variable must be introduced in the teaching structure equation to absorb the excess supply.

5. The transition equation

The fifth and final type of equation is the transition equation. Its purpose is to specify how each time period in the plan is linked together. It is initially assumed that the number of tenure positions in each faculty is never-decreasing, that is

$$TP_t \leq TP_{t+1}$$

The number of non-tenure teachers may however be reduced if excess teaching capacity exists. We assume that the maximal reduction from one period to the following is 30 % of the stock, hence the transition equation for non-tenure teachers becomes

$$NTP_t \leq 1.3 * NTP_{t+1}$$

At a later stage we assume that any overcapacity of tenure positions can be reallocated within the University. The rate of reduction is estimated to approximately 10 %, which corresponds quite well to the average number of annual vacancies.

Planning objectives

The determination of the decision-makers objectives is cumbersome and difficult. Many objectives have been suggested, usually either one which minimizes total cost for a given enrolment or one which maximizes the graduate plus research output for a given budget. The main deficiency in both cases is that the objective implies a well defined relationship between class-size staffing and other inputs and educational outputs. It is however doubtful whether such a simple relationship does exist.

Another and maybe better reason for choosing an alternative objective is the fact that the Danish educational policy has been and still is an open door admission policy. The objective we have chosen is one which minimizes the difference between educational capacity and demand over the faculties. The minimization is not done under a minimum cost assumption but rather under the organizational constraints set by the central decision-maker and/or bargained between him and the faculty members. The objective does not assign any direct value to research activities, mainly because the central decision-maker, in the short run, considers research a necessity rather than an output. The objective is clearly a weak one, but one which is easily understandable.

The research activities should of course be included in the objectives when the decision-maker feels he understands the behavior of the system better than today. It is an essential feature of planning that not only the objective, but also the constraints continuously change as the situation changes.

Time has an impact on the whole university system's behavior. Not only does it take time to train teachers, but more important, once manpower is hired in tenure positions, there is almost no possibility of transferring or dismissing the personnel. Also the teaching process takes several years, and once-admitted students should be permitted to complete the study.

Although the present budgetary system is a rolling-four-year budget, up till now it only acts as a one year plan, mainly because faculty members want to see all their ideas realized as soon as possible.

The possibilities of forecasting the value of some constraints and the knowledge of future budget and manpower ceilings may however lead to a better present decision than a one year plan would. This means that the objective should cover the entire budget period rather than only the first year. When this year is over, a new plan is prepared and the decisions are modified according to the new knowledge and information.

The fact that forecast errors usually increase with time suggests that a decreasing weight is associated with values of the objective function for the future periods. This leads to some sort of a present-value objective. Discounting future expected achievements is also natural, because it is less satisfying to obtain the results tomorrow rather than today.

object $\quad \min \sum_t \beta_t * \sum_i \alpha_i * \text{demand slack}_{it}$

$\beta_1 = 1,\ \beta_t < 1,\ t > 1$

α_i = cost associated to the slack_{it}

demand slack_{it} = number of excess teaching hour demand in the i-te faculty in period t, as defined in the teaching equation.

In this presentation the α's are all equal to 1, that is, all demands have the same priority; it should however be emphasized that the central decision-maker may have reasons to assign higher priorities to unfilled demands in one or more sectors.

In such cases the corresponding α's are set larger than 1, the larger the value the higher the priority.

A Linear Programming Model

With the previously defined constraints and objective equations the planning problem can be solved using linear programming. Linear programming techniques are not the only possible tool for the solution of this kind of problem. Halpern(1) has used network theory to solve a problem of calculating bounds for new faculty positions, a problem which in terms of the constraints, is very similar to the one dealt with in this paper.

More extensive linear programming models have been described by Rasmusen(2) in earlier CERI-project work papers.

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(1) Halpern, Jonathan, "Bounds for New Faculty Positions in a Budget Plan," Paper P-10, The Ford Foundation Project, Berkeley Campus, University of California, May 1970.

(2) Rasmusen, H. J., "Forslag til en decentral budgetlgnings procedure", CERI Report IV, May 1970.
"On Decentralized Planning in a University System", CERI Report X, August 1970.
Both IMSOR, Technical University of Denmark.

Using the IBM MPS/360 programming system, an entire four year plan is solved in approximately 5 seconds.

The following matrix pictures of the planning model explain how all the constraints are built together. Figure IV. 7. 3 shows how the transition equations (the shaded areas) are used to link two consecutive time periods together.

Mathematical structure of the top university level decision-making model (konsistorie level) :

$$\text{Min} \quad \sum A_{tj} C_{tj}$$

$\sum_{k} P_{kj} \cdot S_{tkj} + C_{tj} = U_{tj}$ teaching demand equations

$\sum\sum_{jk} L_{kj} \cdot S_{tkj} \leqslant B_{t}$ cost equations

$\sum\sum_{jk} D_{k} \cdot S_{tkj} \leqslant M_{t}$ manpower equations

$E_{j} \cdot S_{t2j} \leqslant U_{tj}$ bounds on use of non-tenure teachers

$N_{k} \cdot S_{tkj} - S_{t+1kj} \gtrless G_{tkj}$ bounds on changes in activity levels

Indices : k = category of position
1 = tenure, 2 = non-tenure
t = time period
j = Faculty or sector

Coefficients :

P = productivity measure (see Table IV. 7. 2)
U = total teaching demand
L = costs (salary + overheads, see Table IV. 7. 2)
D = 1 for tenure, 0 for non-tenure positions
E = proportion of non-tenure teaching contribution
A = loss associated with the non-satisfied demand
B = total budget quota
M = total manpower quota

Variables :

S = number of manpower positions
C = number of non-satisfied demands

Figure IV.7.3.

THE STRUCTURE OF THE LINEAR PROGRAMMING MODEL

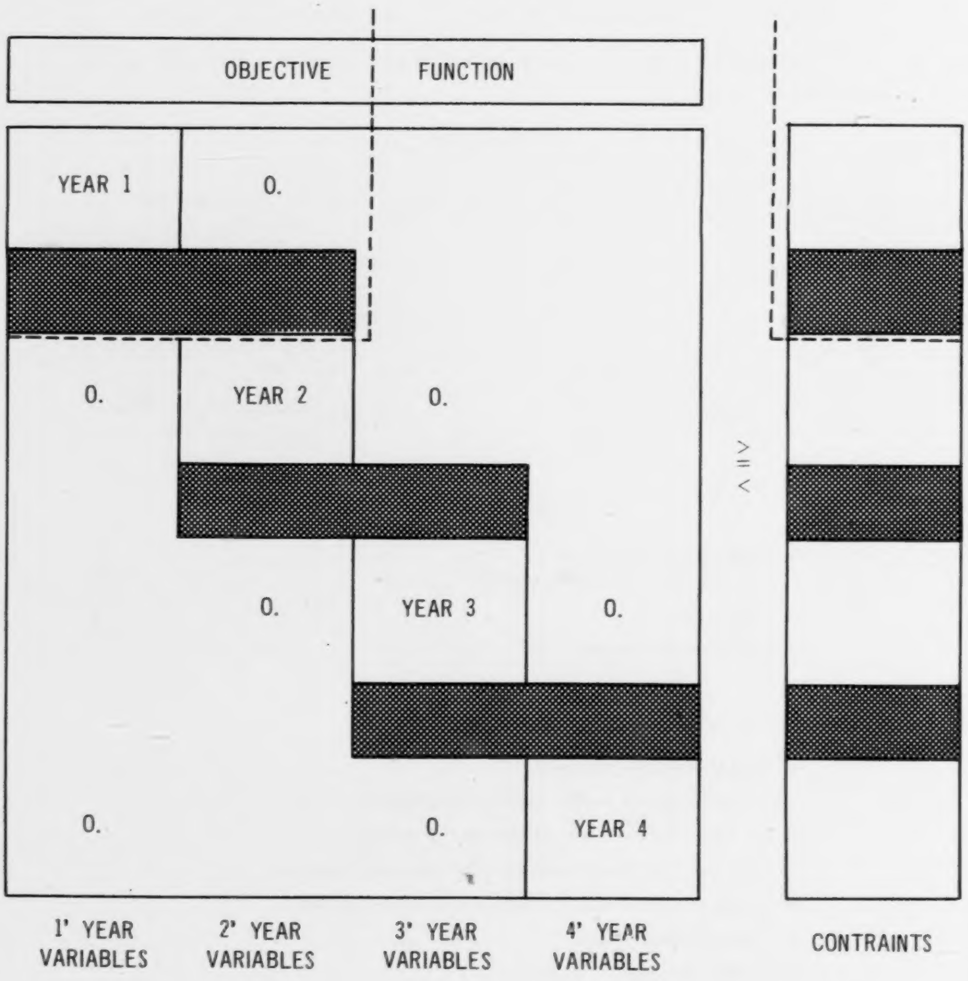
OBJECTIVE FUNCTION
YEAR 1
0.
0.
YEAR 2
0.
0.
YEAR 3
0.
0.
0.
YEAR 4
< = >
1' YEAR VARIABLES
2' YEAR VARIABLES
3' YEAR VARIABLES
4' YEAR VARIABLES
CONTRAINTS

Figure IV.7.4

AN ENLARGED PICTURE OF THE EQUATIONS OF THE FIRST PLANNING PERIOD OF THE MODEL

	COLUMN NAMES YEAR 1																					YEAR 2											RIGHT HAND		
ROW NAMES	SP1	UP1	SM1	UM1	SS1	US1	ST1	UT1	SN1	UN1	PB1	MB1	SB1	TB1	NB1	EXN1	SLP1	SLM1	SLS1	SLT1	SLN1	SP2	UP2	SM2	UM2	SS2	US2	ST2	UT2	SN2	UN2		SIDE VALUES		
MIN KFA																	1.	1.	1.	1.	1.														
PD1	4.38	4.0															1.															≥	4847	Teaching demand weekly hours	Phil. fac.
MD1			2.07	4.0														1.														≥	2648		Med. fac.
SD1					2.66	4.0													1.													≥	1692		Soc. fac.
TD1							3.20	4.0												1.												≥	224		Theol.fac.
ND1									2.54	4.0											1.											≥	2670		Nat. fac.
PC1	91.8	17.7									-1.																					=	0	Cost equation	Phil. fac.
MC1			86.8	22.0								-1.																				=	0		Med. fac.
SC1					118.1	18.2							-1.																			=	0		Soc. fac.
TC1							111.8	22.						-1.																		=	0		Theo'.fac.
NC1									101.1	17.8					-1.																	=	0		Nat. fac.
BU1											1.	1.	1.	1.	1.																	≤	229035	Total budget constraints = 1000 D.kr.	
PO1	1.		1.		1.		1.		1.																							≤	2085	Total manpower constraint.	
UPR1		4.0																														≤	2424	Maximal use of non-tenure teacher weekly hours	Phil. fac.
UMR1				4.0																												≤	1324		Med. fac.
USR1						4.0																										≤	846		Soc. fac.
UTR1								4.0																								≤	112		Theol.fac.
UNR1										4.0						-4.0																≤	1335		Nat. fac.
SP12	1.																					-1.0(-1.1)										≤	0	Transition equations.	
UP12		1.																					-1.3									≤	0		
SM12			1.																					-1.(-1.1)								≤	0		
UM12				1.																					-1.3							≤	0		
SS12					1.																					-1.(-1.1)						≤	0		
US12						1.																					-1.3					≤	0		
ST12							1.																					-1.(-1.1)				≤	0		
UT12								1.																					-1.3			≤	0		
SN12									1.																					-1.(-1.1)		≤	0		
UN12										1.																					-1.3	≤	0		
LOWER BOUND	356	318	540	280	66	175	25	1	961	527																									
	Phil. fac.		Med. fac.		Soc. fac.		Theol. fac.		Nat. fac.		Budget variables					Unfilled demand																			

First character S = tenure positions
First character U = non-tenure teacher

The values in parentheses refer to Table IV.7.8.

Results

The features obtained by using mathematical programming techniques can be classified into two groups. The first group is the unique possibility of selecting one solution among an infinite number of possible solutions. This is also referred to as the selection of an optimal plan.

The second group of features is the so called post-optimal or sensitivity analysis, which permits the analyst to analyse how a certain small change in one or more data elements of the model is influencing the value of the objective function and the plans selected.

This information is particularly helpful if the decision maker has to enter into discussion both with his superiors and his subordinates.

Table IV. 7. 6 summarizes the optimal allocation of manpower etc. obtained by running the linear programming model using the forecasts for budget and manpower ceilings in Table IV. 7. 5 and the demand forecasts of Table IV. 7. 1

Table IV. 7. 5 - Total budget ceiling forecast in mill. Danish Kroner

1969/70	1970/71	1971/72	1972/73
229. 035	241. 753	254. 800	272. 950

Total manpower ceiling forecast

1969/70	1970/71	1971/72	1972/73
2085	2190	2310	2460

Table IV. 7. 6 shows some very interesting results. We notice a very rapid expansion of the staff in the Philosophy Faculty, a high expansion rate is also noted in the Social Science Faculty, particularly at the end of the planning horizon. The number of tenure positions in the Medical Science Faculty and in the Natural Science Faculty are held constant, and in the first three years the Natural Science Faculty is even reducing its over-capacity of non-tenure teachers.

These results differ very much from the current development in the appointments of new positions, where the largest part of the expansion has been going to the Medical and Natural Science Faculties, which, as shown in the forecasts by Hammer-Jespersen, is going to sustain the current unequal distribution of resources.

Table IV. 7. 6 - Optimal allocation of staff

1972/73

		Initial	year 1	year 2	year 3	year 4
Philosophy	tenure position	356	461	598	639	689
faculty	non-tenure teach.	318	606	660	700	755
Medicine	tenure position	540	540	540	540	540
faculty	non-tenure teach.	280	331	336	354	372
Social Science	tenure position	66	66	66	142	242
faculty	non-tenure teach.	175	212	221	235	245
Theology	tenure position	25	25	25	27	27
faculty	non-tenure teach.	1	28	27	21	21
Natural Science	tenure position	961	961	961	961	961
faculty	non-tenure teach.	527	527	465	396	407

Table IV. 7. 7. shows how the balancing of supply and demand is performed by the model. The discounted sum of total unsatisfied demands is computed to 3434 weekly hours, using a discount factor of 10% p. a. No effort has been made in order to determine a proper discount factor. The common impatience among university people does however suggest a relatively high discounting value.

Positive values indicate excess supply and negative values indicate excess demand compared with the expected demands of Table IV. 7. 1.

From Table IV. 7. 7. we learn that the demands in the Philosophy Faculty are filled within the first two planning periods. The same is the case in the Theology Faculty. The excess capacity in the Natural Science Faculty is gradually levelled off, however there still remains demand in the Social Science Faculty and in the Medical Science Faculty, where the demand is even increasing.

Why is the model unable to transfer the excess capacity in the Natural Science Faculty to the two faculties still demanding resources ?

Table IV. 7. 7 - The distribution of under- and overcapacity

(No reallocation of tenure positions)

	year 1	year 2	year 3	year 4
Philosophy faculty	- 403	- 23	0	0
Medicine faculty	- 206	- 228	- 300	- 372
Social Science faculty	- 670	- 711	- 563	- 335
Theology faculty	- 36	- 39	0	0
Natural Science faculty	+ 1879	+ 1257	+ 914	+ 675

The reason is simply that there is a high demand for tenure positions in the 2nd, 3rd, and 4th planning period, and that both the Medical and the Social Science Faculties are unable to take more non-tenure teachers on without violating the teaching structure constraints.

A better total solution can be obtained if it is permitted to release some tenure positions at the end of each year.

Table IV. 7. 8. shows how the excess demands and supplies are distributed when a 10% stock reduction is permitted for the tenure positions in the transition equations.

Table IV. 7. 8 - The distribution of under- and overcapacity

(Max 10% reduction of tenure stocks in each period)

	year 1	year 2	year 3	year 4
Philosophy faculty	- 403	0	0	0
Medicine faculty	- 206	- 212	- 212	- 124
Social Science faculty	- 670	- 526	- 232	- 19
Theology faculty	- 36	- 24	0	0
Natural Science faculty	+ 1879	+ 796	+ 155	0

This solution is obviously better than the previous one, however the teaching demand in the Medical Science Faculty is still going through a period of increasing demand. This anomaly is simply caused by the fact that this faculty is the least profitable one to allocate resources to in terms of teaching output. The Medical Science Faculty not only has the lowest teaching output per tenure position, but also the highest cost per non-tenure teacher.

Shadow prices

The shadow prices on the scarce resources are very important control parameters in a quota controlled decentralized system, as the one proposed in this paper.

Table IV. 7. 9 shows how the shadow prices on the total manpower and budget constraints develop over a planning period.

Table IV. 7. 9 - Shadow prices

	year 1	year 2	year 3	year 4	
tenure positions	0	3. 94	2. 15	1. 94	weekly hours per pos.
budget	0. 0476	0	0	0	weekly hours per 1000 Danish Kroner

The shadow price indicates how much the objective function is improved if the constraint to which the shadow price corresponds is relaxed by one unit.

A high shadow price shows that the constraint is tight and that a small relaxation will lead to a large improvement. When a shadow price equals 0 it indicates that there is an excess supply of that particular type of resource.

From Table IV. 7. 9. we thus learn that the operation budget is the tight resource in the first year, but that the manpower constraint is the tight constraint in year 2, 3, and 4. We come to the same conclusion by examining Table IV. 7. 7.; however the numeric values of the shadow price lead to a quantitative description of the tightness of the constraint.

Further notes on the application of the shadow prices will be given in a subsequent section on the implementation.

Sensitivity Analysis

The derivation of shadow prices is one way of judging the sensitivity of the solution. The computations behind Table IV. 7. 8. show how a 10% change in some of the coefficients of the transition equations greatly affects the total result of the solution.

The linear programming procedures usually offer a large range of possible analyses. Since this model is based upon forecasted future teaching demands, one could ask how sensitive the solution is in terms of fluctuations in the demand. Although such an analysis is highly relevant it requires a lengthy description of the results as well as the interpretation.

Instead we assume that the top decision making body of the University as a contingency wants to prepare a plan with 1% lower budget ceilings. In doing so the decision-maker learns something about the sensitivity of the solution in terms of the budget ceilings. A 1% reduction of the total operation budget is not very much ; however in a marginal budgetary system with approximately 10% annual growth this equals a 10% reduction of the growth rate, which has been imposed a few times in the recent years.

Table IV. 7. 10. gives the new optimal allocation of tenure and non-tenure staff after a 1% reduction of the total operation budget.

Table IV. 7. 10 - Optimal allocation of staff

		Initial	year 1	year 2	year 3	year 4
Philosophy	tenure position	356	436	583	639	689
faculty	non-tenure position	318	606	661	700	755
Medicine	tenure position	540	540	540	540	540
faculty	non-tenure position	280	331	336	355	372
Social Science	tenure position	66	66	66	134	242
faculty	non-tenure position	175	211	221	235	245
Theology	tenure position	25	25	25	27	27
faculty	non-tenure position	1	28	27	21	21
Natural Science	tenure position	961	961	961	961	961
faculty	non-tenure position	527	527	405	312	254

A comparison between Table IV. 7. 10 and Table IV. 7. 6 reveals that the terminal year does not differ very much in the two solutions. The expansion rate over the planning period is however different.

The compensation of the reduced budget is realized mainly by the reduction of the stock of non-tenure teachers in the Natural Science Faculty.

Table IV. 7. 11 shows the distribution of excess demand and supply.

Table IV. 7. 11 - The distribution of under- and overcapacity

	year 1	year 2	year 3	year 4
Philosophy faculty	- 513	- 87	0	0
Medicine faculty	- 206	- 228	- 300	- 373
Social Science faculty	- 670	- 711	- 589	- 335
Theology faculty	- 36	- 40	0	0
Natural Science faculty	+ 1879	+ 1018	+ 578	+ 64

Also Table IV. 7. 11 shows how resources are shifted away from the Natural Science Faculty, and that the total system apparently over a 5 or 6 year period is able to absorb a reduction of the operation budget in the order of 1%.

Table IV. 7. 12 finally displays how the shadow prices of the manpower and budget constraint are affected by the 1% reduction of the operation budget.

Table IV. 7. 12 - Shadow prices

	year 1	year 2	year 3	year 4
tenure position	0	0	0	1. 94
budget	0. 0476	0. 0429	0. 0182	0

Even a small reduction of the operating budget is able to take the pressure off the manpower constraint, thus leading to an excess supply of tenure manpower positions in the first three planning years.

Some comments on the derived solutions

Once the general ideas behind this model have been explained it is natural to raise the question, what happens to the excess demand ?

The existence of non-zero values in the objective function indicate that the open door admission policy is not fulfilled. In real life students are hardly ever refused participation in education due to excess demands. An easy way of reducing the value of the objective function is to increase the class-sizes until a point is reached where all demand is satisfied.

A real life satisfaction of the demand may also be realized if the tenure faculty members engage more in teaching than assumed in this model.

Both the tendency to increase class-size and the teaching load of the tenure faculty may easily lead to a general reduction of the educational quality, which usually is an unsatisfactory state.

If we assume that all students should be taught under an equal quality assumption, then any unfilled demand cannot be satisfied until, at the earliest, the following time period. The total demand in any time period is thus equal to the computed demand for that period plus the unfilled demand from the previous period.

$$\text{true demand}_t = \text{compt demand}_t + \text{unfilled demand}_{t-1}$$

This formulation is possibly the most reasonable one to assume and it is easy to modify the demand equation accordingly(1).

Another question, which may be raised when the objective function shows non-zero values, is whether the students will find it tempting to switch from a faculty with a high value of the objective function to a faculty with a lower value, or whether the students are insensitive to the possible troubles of getting through the system. If the students are sensitive to the troubles of getting through, this in fact will lead to a complication of the planning problem because it will introduce dependencies between the needs of the faculties, which in turn will make it more difficult to estimate the demands. Further research is needed in this area before such problem can be solved.

The length of the planning horizon has quite arbitrarily been fixed to four years because the current budgetary system is a rolling four-year procedure. It is however quite reasonable to ask whether or not a longer time span would be more correct.

Since no upper bounds have been introduced upon the increase in tenure and non-tenure positions from one year to the following, no changes in the solution can be expected because more years are included in the plan. This argument also holds if the number of years are reduced. This does certainly not mean that no upper bounds exist on the transition equation ; quite the contrary, it might be very difficult to realise the growth rates listed in Table IV.7.6 because of the large drain in the academic labour market. The model can easily be modified to incorporate upper bounds on growth.

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(1) This formulation also allows an interpretation in which any unsatisfied demand leads to an increasing number of repeaters who add to the demands in the following year.

On the other hand one could argue that the planning horizon at least should be as long as required to satisfy all demands. This would give any party involved on the decision process clear information on when and how the demands are to be fulfilled.

Implementation

The implementation of a tactical resource allocation procedure as the one proposed in this paper definitely creates several problems of its own.

Not only do we deal with a total point of view, apart from the current partial one, but the solutions are, as a consequence of the former property, highly incongruent with the most recent decision patterns.

It was emphasized in the introduction that one of the advantages gained by using decentralized planning was the reduced need for communication between two decision levels. This advantage is not fully gained in this procedure because the model is solved centrally by the top decision making body of the University. This in turn changes the use of the procedure slightly.

The main decentralization properties are however still maintained, partly because the procedure deals with resource ceilings and not with specific projects, and partly because the technical coefficients used can undergo modifications as a result of negotiations between the two levels.

The information and data obtained from the solution may be used in two different decision processes. One is the upward (external) negotiation with the Ministry of Education and the other is the downward (internal) negotiation with the faculties.

Internal use

With a centrally solved model the main internal use of this procedure is the possibility to compute an "opening bid" for the bargaining around the tactical resource allocations.

It is very likely that the dramatic reduction of the number of tenure and non-tenure positions of the Natural Science Faculty may prove to be organizationally unfeasible. However the reallocation of at least some resources may by accomplished by other means as for instance a reduction of the research overheads. Such an approach may be easier to negotiate.

The relatively poor performance in the Medical Science Faculty may be improved either by an increased productivity per tenure position, i. e. a reduction of the number of non-academics, or by a substitution by cheaper non-tenure teachers for part of the expensive ones used now, or some combination of these approaches.

The main internal use of this planning procedure will thus, in the first phases of implementation, be to serve as some kind of a monitoring device or tool by which the top decision making body can supervise the performance of the system. The computational results obtained also suggest that this planning procedure is an excellent tool for the evaluation of new policies aimed towards a better internal resource allocation and hence towards better achievements of the entire University.

External use

The results obtained by using this planning model can not only be used internally in the University ; the results are also excellent data for the negotiations with the Ministry of Education. This Ministry can obviously not reach an optimal allocation of its resources in the very first allocation in the process of the preparation of the budget.

When the initial ceilings have been received by the University, the model is run, and an optimal solution is derived. This solution does most likely show some unfilled demands, particularly in the first planning year. The top University decision making body can now approach the Ministry of Education and not only argue for more resources to fill the demands, but the resource demands can be quantified by applying the corresponding shadow prices.

If the results of Table IV. 7. 9 represent a real-life case, there is obviously no point in asking for further manpower positions for the first planning year, because the shadow price is 0. Actually the corresponding solution shows an excess of 31 positions.

When the Ministry of Education reviews the shadow prices from all universities, they may find some with high demand (shadow prices) upon manpower positions and some with low shadow prices upon the operating budget. They can now initiate a reallocation of the initial ceilings in such a way that resources are moved from places with low prices to places with high shadow prices.

After each iteration all universities must solve their model and compute a new set of shadow prices, which in turn are sent to the Ministry for further consideration. This procedure is the Kornai-Liptak decentralization procedure. (See also Figure IV. 9. 6 in Part IV, Chapter 9).

If implemented, such a procedure must naturally converge very rapidly, because nobody can be assumed to accept more than two or three revisions of a tactical operation plan which is developed annually. We must assume that the convergence process can be greatly improved as the Ministry of Education uses a similar procedure for the computation of its "opening bid".

Three level planning

At a later stage of the implementation the proposed planning procedure can be used in a more sophisticated way(1).

In order to understand this application it is necessary to recall that the internal pricing and the quota control approaches are dual formulations of the same problem. At an optimal solution the internal price and the shadow price of a resource becomes identical. Thus when the allocation problem is solved, the obtained shadow prices can be used as an opening bid for the internal price to be used in the decentral planning at the faculty level.

When a faculty develops its plan or proposed plan the achievements of the plan are evaluated in terms of its teaching output in hours. This performance measure represents the value of the plan if no resource scarcity had existed. However since there is a general lack of resources, the value is reduced in proportion to the use of scarce resources.

High-valued plans which only require a small amount of resources maintain a high value, but high valued plans which require a large amount of resources obtain a reduced value. The proportionality factor associated to each type of resource is the internal price.

In a mathematical formulation the modified objective function becomes

mod. plan. value = plan. value - internal price X amount of resource used.

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(1) See also : Weitzman, Martin, "Iterative Multilevel Planning with Production Targets," Econometrica, Vol. 38, no. 1., 1970.

When the internal pricing technique is used in a mathematical programming procedure it is usually referred to as Dantzig-Wolfe decomposition.

Assume that the internal prices have been computed centrally and that each faculty knows the prices before it submits its budget proposals. Let us further assume that each faculty considers its initial state "optimal", that is, it will argue that any increase in the teaching demand will require an equal increase in the supply of resources. Let us finally assume, as a matter of simplicity, that both the Natural Science Faculty and the Philosophy Faculty expect a 10% increase in the demands for 1969/70 over that of 1968/69.

Table IV. 7. 13

	1968/69		1969/70	
	Demand	Oper. budget	Demand	Oper. budget
Philosophy	2812	38. 3 mill	3100	41. 1 mill
Natural Science	4544	106. 6 mill	5000	117. 4 mill

Only the operating budgets are listed in Table IV. 7. 13 because the internal price (shadow price) in Table IV. 7. 9. is zero for the tenure positions. The modified value of the plans from the two faculties is now obtained using the internal price on the operating budget listed in Table IV. 7. 9.

Philosophy Faculty mod. value $= 3100 - 47.6 * 41.4$
$= 3100 - 1960$
$= 1140$

Natural Science Faculty mod. value $= 5000 - 47.6 * 117.4$
$= 5000 - 5580$
$= - 580$

Before the Natural Science Faculty submits its budgetary proposal it now knows that the way it had decided to fill the demands is highly uneconomical. The negative value of the modified objective function indicates an excess use of resources. The inefficiency is of course even more pronounced when the centrally computed demand figures are substituted into the equation.

The modified plan value of the Philosophy Faculty does on the other hand still indicate a positive value. This faculty could in fact use more resources and still maintain a positive value. When the centrally computed expected demands are substituted into the equation, the modified value is even higher. Thus the Philosophy Faculty knows before it submits its budgetary plan that it has a high value, viewed from the top decisionmaking body of the University.

As a closing remark it should be emphasized that both the initial internal price and the initial allocation of the resource ceilings (quotas) are tentative, that is, they undergo changes during the tactical planning phase in accordance with new plans and new demand calculations and possibly even new policies.

Summary

This planning procedure has been designed as an analytical tool to be used at the highest decision making level of a university. At this decision level, planning and decision making is assumed to operate in a highly decentralized manner, with few and very aggregated decision variables.

The planning problem attacked is the resource allocation problem which originates from an intention to allocate resources in a way yielding an overall best match between teaching supply and demand.

The planning is thus done from a total budgeting point of view rather than the current marginal budgeting approach. Research is handled as incurred activities and costs, as an attempt on one hand to give the scientist an ultimate degree of research freedom and on the other hand to escape the research/ teaching evaluation problem.

Most tactical resource allocations problems in a university are in one way or another dealing with manpower allocations ; it is however much easier to hire than to dismiss or transfer personnel. Thus the easiest way to control the system is through a control of the growth. Based upon estimates of future teaching demands and available resources the planning procedure determines when and in what quantity the resources should be allocated to the divisions of the university in order to obtain the best overall plan.

In order to simplify the initial data collection, the traditional division of the University of Copenhagen into five faculties has been used in this model, however 10 or 15 decentral sectors are more likely to reflect the de-facto number of independent main areas of study.

The planning procedure is designed around a linear programming model, covering all four years of the budgetary period. The model has been developed in a way securing a high degree of compatibility with other models developed under this CERI project.

An analysis of the initial resource distribution shows that one faculty has a large excess supply, one is balancing and three are highly under supplied. However the total available supply turns out to be only 7% lower than the total computed demand.

Through a proper use of the marginal resources and reallocation of some of the non-tenure teachers it is possible to attain an almost ideal resource distribution before the end of the four year period.

By permitting a reallocation of tenure positions becoming vacant during the planning horizon, the supply and demand matching process can be greatly improved.

It is further shown how the planning procedure can be applied in the evaluation of new policies and as a monitoring device in the negotiation and bargaining phase of the budgetary process.

It is particularly emphasised how the shadow prices on the scarce common resources can be used as a quantitative indicator of the scarcity.

No planning procedure or its solutions are any better than the data applied, thus it is necessary continuously to control that the numbers used are representative. It is particularly important to ensure that the data is as little biased as possible; it will for instance be necessary to develop a control procedure, which can compare once-forecasted demands with those actually measured some time later, in order to reveal whether or not the differences are random or systematic.

Chapter 8

MOVING DECISIONS BETWEEN MANAGEMENT LEVELS WITH CONFLICTING OBJECTIVES

by

Bo Munch-Andersen

Abstract

A model has been developed with the purpose to analyse the effect of moving decisions from one level of university management to another.

The decisions considered here are the allocations of two types of resources, manpower and money, to a set of activities. The two levels of management are assumed to have different preferences as to the allocation of resources on the activities. In the model, the upper level management first allocates a certain portion of the available resources, and subsequently the lower level management allocates the remaining portion of resources. Both managements attempt to minimize the deviation of the resulting combined allocation from their particular preferred allocation.

Changing the upper level portion of available resources from none to all of it, the model calculates the resulting combined allocation and measures for the deviation from the preferred allocations.

Introduction

The over-all objective of a public university is very complex and is composed of many single objectives of which several are in conflict with each other. The conflicting objectives can be associated with each of the many social groups for whose benefit the public spends resources on research and higher education. A classification into such social groups could be :

> The public as a whole, wanting graduates and research achievements in the most demanded fields.
>
> The university teachers, each wanting to do research and to teach in the fields of their own choice.

The students, each wanting education in the fields of his own choice.

If the various social groups have different objectives, they will also have different opinions about the resource allocation,since a certain allocation of resources indirectly is an expression of a certain objective.

The influence of the various social groups on the resource allocation within a university depends on how these social groups are represented in the decision making units and which decisions fall under these units.

The purpose of the present research work has been to develop a mathematical decision model to analyse the effect on the resource allocation when decisions are moved from one decision making unit to another. The work has been inspired by the strong interest in this matter repeatedly expressed by Professor Erling Olsen, Rektor of Roskilde University. Specific attention will be paid to the case where decisions can be moved from one level of university management to another.

The basic method for resource allocation in the higher education system in Denmark is the "ceiling system", where a management at a given level receives a ceiling of resources and divides this into smaller ceilings for other managements at the next lower level. But besides this ceiling system there exists the possibility that a management can "earmark" a portion of the available resources for certain activities. If an upper level management has objectives conflicting with those of a lower level management, a change in size of the earmarked portion of resources will affect the resource allocation and thus the objectives of both managements. The developed mathematical model can be used to evaluate quantitative measures for the objectives for varying portions of earmarked resources.

A case of resource allocation with conflicting objectives

To stimulate the readers interest before we start with formal mathematical generalizations, let us consider Table IV. 8. 1. presenting a simplified example (1) of a one year budget at the University of Copenhagen, where details of sub-budgets are shown for the Natural Science Faculty.

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(1) In Tables IV. 8. 1-3 the ceilings and the costs per unit are chosen to be realistic in size (in 1971-prices for the year 1972/73),but all preferred allocations are imaginary and have not necessarily any relation to the preferences in the real decision making units.

Table IV. 8. 1 - One year budget, University of Copenhagen

	Tenure positions	Cost mill. Danish Kroner
University of Copenhagen, total	2788	359. 0
1. Philosophy Faculty	510	65. 9
2. Medical Faculty	773	89. 9
3. Social Science Faculty	94	16. 5
4. Theology Faculty	35	4. 7
5. Natural Science Faculty	1376	182. 0
5. 1 Full Professors, 90 at d. kr. 138. 000 .	90	12. 4
5. 2 Associate Professors, 90 d. kr. 105. 000 .	90	9. 5
5. 3 Assistant Professors, 491 - 85. 000 .	491	41. 7
5. 4 Part-time Lecturers, 238 - 26. 000 .	0	31. 0
5. 5 Teaching Assistants, 520 - 19. 000 .	0	6. 2
5. 6 Non-academics, 705 - 44. 000 .	705	9. 9
5. 7 Large Apparatus	0	51. 3
5. 8 Annua	0	20. 0

Many social groups are affected by the composition of the above budget, but only a few can influence it. Let us consider the following three decision-makers :

The Ministry of Education.

The Konsistorium at the University of Copenhagen.

The Natural Science Faculty Board.

Suppose now that the allocation of resource ceilings during the budget process takes place in the following order :

1. The Ministry of Education has fixed a manpower and a budget ceiling for the University of Copenhagen.
2. The Ministry of Education earmarks a portion of the resource ceilings for the various faculties.
3. The Konsistorium allocates the not earmarked resources among the faculties.
4. The result of step 2 and 3 is a set of resource ceilings for each faculty.

5. The Konsistorium earmarks a portion of the faculty resource ceilings to certain budget categories.

6. The faculty boards allocate the not earmarked resources to the budget categories.

7. The result of step 5 and 6 is the final budget for the faculties.

Case 1 (Step 1 - 4) :

The manpower and budget ceilings for University of Copenhagen have been fixed to 2788 tenure positions and 359 million danish kroner. Assume now that the Ministry of Education and Konsistorium have different opinions about the distribution of resources between the faculties, but that the Ministry of Education is indifferent as to the distribution between the various budget categories within the faculties. Let the different opinions be quantified as the preferred allocations shown in Table IV. 8. 2. Both of these allocations keep within the resource ceilings and have for any given faculty the same average cost per tenure position. As the first case we will analyse the effect on the budget of letting the Ministry of Education earmark more or less of the resources to the faculties.

Case 2 (Step 4 - 7) :

Consider now the sub-budget for the Natural Science Faculty for given manpower and budget ceilings of 1376 tenure positions and 182 million danish kroner. This corresponds to the preferred allocation of Konsistorium in Table IV. 8. 2. Assume that Konsistorium and the Natural Science Faculty Board have different opinions about the distribution of resources between the budget categories and let these opinions be quantified as the preferred allocations shown in Table IV. 8. 3 Again the preferred allocations keep within the ceilings and are based on same cost per unit for any given budget category. We shall as our second case analyse the effect on the sub-budget of the Natural Science Faculty of letting the Konsistorium earmark more or less of resources to the budget categories.

Table IV. 8. 2 - Preferred allocations, case 1

Faculty	Average cost per tenure position 1000 danish kroner	Ministry of Education		Konsistorium	
		Preferred no. of positions	Cost Mill. danish kroner	Preferred no. of positions	Cost Mill. danish kroner
Philosophy	129	1230	158.7	510	65.9
Medicine	116	570	66.1	773	89.9
Social Science	175	420	73.5	94	16.5
Theology	134	45	6.0	35	4.7
Natural Science	132	414	54.7	1376	182.0
Total		2679	359.0	2788	359.0

Table IV. 8. 3 - Preferred allocations, case 2

Budget categories	Tenure positions per unit	Average cost per unit 1000 danish kr.	Preferred no. of units	Konsistorium		Natural Science Faculty Board		
				Tenure positions	Cost mill. danish kroner	Preferred no. of units	Tenure positions	Cost mill. danish kroner
Full Professors	1	138	90	90	12. 4	110	110	15. 2
Associate Professors	1	105	90	90	9. 5	200	200	21. 0
Assistant Professors	1	85	491	491	41. 7	300	300	25. 5
Part-time Lecturers	0	26	238	0	31. 0	400	0	10. 4
Teaching Assistants	0	19	520	0	6. 2	200	0	3. 8
Non-academics	1	44	705	705	9. 9	766	766	33. 7
Large Apparatus	0	100	513	0	51. 3	424	0	42. 4
Annua	0	100	200	0	20. 0	300	0	30. 0
Totals				1376	182. 0		1376	182. 0

Mathematical model of two-level resource allocation with conflicting objectives

Let us introduce some mathematical notation :

n : Number of activities (entries in the budget)

z_i : Ceiling for resource type i (1 for manpower, 2 for budget)

a_{ij} : Amount of resource type i required per unit of activity j

c_{1j} : Number of units of activity j preferred by first decision maker

c_{2j} : Number of units of activity j preferred by second decision maker

x_j : Number of units of activity j allocated by first decision maker

y_j : Number of units of activity j allocated by second decision maker

P : Relative portion of resources allocated by first decision maker (earmarked portion), $0 \leqslant p \leqslant 1$

$$\bar{c}_1 = \left\{c_{11}, c_{12}, \ldots, c_{1n}\right\} \qquad \bar{x} = \left\{x_1, x_2, \ldots, x_n\right\}$$

$$\bar{c}_2 = \left\{c_{21}, c_{22}, \ldots, c_{2n}\right\} \qquad \bar{y} = \left\{y_1, y_2, \ldots, y_n\right\}$$

The first decision maker's allocation, $\bar{x}$, must satisfy the constraints :

$$\begin{aligned} \sum_{j=1}^{n} x_j a_{ij} &\leqslant p z_i \qquad && i = 1, 2 \\ x_j &\geqslant 0 && j = 1, 2, \ldots, n \end{aligned} \qquad (1)$$

The second decision maker's allocation, $\bar{y}$, must satisfy the constraints :

$$\begin{aligned} \sum_{j=1}^{n} y_j a_{ij} &\leqslant (1-p) z_i \qquad && i = 1, 2 \\ y_j &\geqslant 0 && j = 1, 2, \ldots, n \end{aligned} \qquad (2)$$

Let $\bar{r} = \bar{x} + \bar{y}$ be the final combined allocation.

We will measure the deviation of an actual allocation $\bar{r}$ from a preferred allocation $\bar{c}$ by a deviation measure $K(\bar{r}, \bar{c})$, which for the present application has been chosen to be :

$$K(\bar{r}, \bar{c}) = \sum_{j=1}^{n} w_j \left[\frac{|D(PRE_j - RES_j)|}{PRE_j} \right]^2 \qquad (3)$$

where

$$w_j = \frac{|PRE_j|}{\sum_{j=1}^{n} |PRE_j|}$$

$$PRE_j = \left\{ \frac{c_j a_{1j}}{z_1}, \quad \frac{c_j a_{2j}}{z_2} \right\} \text{(a two-dimensional resource vector)}$$

$$RES_j = \left\{ \frac{r_j a_{1j}}{z_1}, \quad \frac{r_j a_{2j}}{z_2} \right\} \text{(a two-dimensional resource vector)}$$

$D(\bar{v})$ and $|\bar{v}|$ are defined for a vector $\bar{v} = \{v_1, v_2, \dots v_n\}$ as

$|\bar{v}| = \sqrt{\sum_{i=1}^{n} v_i^2}$ (the length of the vector), and

$$D(\bar{v}) = \{d(v_1), d(v_2), \dots\dots\dots, d(v_n)\} \quad \text{where}$$

$$d(v_i) = \begin{cases} v_i \text{ if } v_i > 0 \\ 0 \text{ if } v_i \leqslant 0 \end{cases}$$

The expression (3) can be reduced to

$$K(\bar{r}, \bar{c}) = \sum_{j=1}^{n} w_j \left[\frac{d(c_j - r_j)}{c_j}^2 \right]$$

This deviation measure can be expressed verbally as being the weighted sum of the squares of the negative deviations, where the weight factors are equal to the normalized lengths of the preferred resource vectors.

Each of the two decision makers attempts to minimize the deviation measure for their preferred allocation.

In this model we assume that the first decision maker does not utilize any knowledge about the preferences of the second decision maker and uses a "minimax" strategy, thus choosing the allocation minimizing the maximum possible deviation measure, i. e.

$$\min_{\bar{x}} \max_{\bar{y}} K(\bar{x} + \bar{y}, \bar{c}_1)$$

Using the deviation measure expression (3), $K(\bar{x} + \bar{y}, \bar{c}_1)$ is maximized for $\bar{y} = 0$. Thus the optimal allocation, $\bar{x}$, can be found simply from

$$\min_{\bar{x}} K(\bar{x}, \bar{c}_1)$$

subject to the conditions (1).

On the other hand we assume that the second decision maker fully uses the knowledge about the first decision makers allocation and thus for a given $\bar{x}$ chooses the allocation $\bar{y}$ from

$$\min_{\bar{y}} K(\bar{x} + \bar{y}, \bar{c}_2)$$

subject to the conditions (2).

For given values of p, z_1, z_2, $\bar{\bar{a}}$, $\bar{c}_1$ and $\bar{c}_2$ a computer program has been developed to evaluate the final combined allocation $\bar{r} = \bar{x} + \bar{y}$ and deviation measures and $K(\bar{r}, \bar{c}_2)$.

The minimizations in the model are performed by a dynamic programming algorithm.

To provide for a gross measure of deviation for the first decision maker in the case when the activities can be aggregated into main groups of activities, the following expression has been developed. A slightly changed notation is used

n : Number of main groups of activities.

mj : Number of activities in main group j, $\bar{m} = \{m_1, m_2, \ldots, m_n\}$

a_{ijk}, c_{jk}, r_{jk} : Same meaning as the previous a_{ij}, c_j and r_j, but where the combination jk now means activity k within main group j.

Gross deviation measure :

$$K_G (\bar{r}, \bar{c}, \bar{m}) = \sum_{j=1}^{n} w_j \left[\frac{|D(PRE_j - RES_j)|}{|PRE_j|} \right]^2 \qquad (4)$$

where w_j, D and $|\quad|$ and are defined as in (3)

but the definition of PRE_j and RES_j is changed to :

$$PRE_j = \sum_{k=1}^{m_j} PRE_{jk} \;, \quad PRE_{jk} = \left\{ \frac{c_{jk}\, a1_{jk}}{z_1} \,, \frac{c_{jk}\, a2_{jk}}{z_2} \right\}$$

$$RES_j = \sum_{k=1}^{m_j} RES_{jk} \; , \quad RES_{jk} = \left\{ \frac{r_{jk}\, a1_{jk}}{z_1} \; , \; \frac{r_{jk}\, a2_{jk}}{z_2} \right\}$$

The computer program can evaluate this gross deviation measure for a given grouping $\bar{m}$.

Results

Case 1 :

The computer program was run with

$z_1 = 2788$ (positions)

$z_2 = 359,000$ (1000 danish kroner)

$$\bar{\bar{a}} = \left\{ \begin{matrix} 1 & 1 & 1 & 1 & 1 \\ 129 & 116 & 175 & 134 & 132 \end{matrix} \right\}$$

$$\bar{c}_1 = \left\{ 1230 \quad 570 \quad 420 \quad 45 \quad 414 \right\}$$

$$\bar{c}_2 = \left\{ 510 \quad 773 \quad 94 \quad 35 \quad 1376 \right\}$$

The results are shown in Table IV. 8. 4 and Figure IV. 8. 6.

Case 2 :

The computer program was run with

$z_1 = 1376$ (positions)

$z_2 = 182,000$ (1000 danish kroner)

$$\bar{\bar{a}} = \left\{ \begin{matrix} 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 138 & 105 & 85 & 26 & 19 & 44 & 100 & 100 \end{matrix} \right\}$$

$$\bar{c}_1 = \left\{ 90 \quad 90 \quad 491 \quad 238 \quad 520 \quad 705 \quad 513 \quad 200 \right\}$$

$$\bar{c}_2 = \left\{ 110 \quad 200 \quad 300 \quad 400 \quad 200 \quad 766 \quad 424 \quad 300 \right\}$$

$$\bar{m} = \left\{ 3 \quad 2 \quad 1 \quad 2 \right\}$$

The results are shown in Table IV. 8. 5. and Figure IV. 8. 7.

Table IV. 8. 4 - Results, case 1

p	Combined allocation ($\bar{x} + \bar{y} = \bar{r}$)			
	0 %	40 %	70 %	100 %
Philosophy Faculty	0 + 510 = 510	513 + 0 = 513	836 + 0 = 836	1230 + 0 = 1230
Medical Faculty	0 + 773 = 773	243 + 504 = 747	429 + 119 = 548	570 + 0 = 570
Social Science Faculty	0 + 94 = 94	123 + 0 = 123	287 + 0 = 287	420 + 0 = 420
Theology Faculty	0 + 35 = 35	17 + 18 = 35	31 + 0 = 31	45 + 0 = 45
Natural Science Faculty	0 + 1376 = 1376	180 + 1122 = 1302	280 + 705 = 985	414 + 0 = 414
Deviation Measures, $K(\bar{r}, \bar{c})$				
Ministry of Education	0. 267	0. 245	0. 066	0
Konsistorium	0	0. 002	0. 065	0. 264

p : Earmarked portion of resources.

$\bar{x}$: Positions allocated by the Ministry of Education.

$\bar{y}$: Positions allocated by Konsistorium.

Table IV. 8. 5 - Results, case 2

	Combined allocation ($\bar{x} + \bar{y} = \bar{r}$)			
	0 %	70 %	85 %	100 %
Full Professors	0 + 110 = 110	60 + 46 = 106	72 + 23 = 95	90 + 0 = 90
Associate Professors	0 + 200 = 200	60 + 128 = 188	72 + 90 = 162	90 + 0 = 90
Assistant Professors	0 + 300 = 300	320 + 0 = 320	418 + 0 = 418	491 + 0 = 491
Part-time Lecturers	0 + 400 = 400	162 + 210 = 372	198 + 140 = 338	238 + 0 = 238
Teaching Assistants	0 + 200 = 200	444 + 0 = 444	396 + 0 = 396	520 + 0 = 520
Non-academics	0 + 766 = 766	510 + 224 = 734	585 + 90 = 675	705 + 0 = 705
Large Apparatus	0 + 424 = 424	360 + 44 = 404	432 + 0 = 432	513 + 0 = 513
Annua	0 + 300 = 300	125 + 145 = 270	180 + 68 = 248	200 + 0 = 200
Deviation Measures $K(\bar{r}, \bar{c})$				
Konsistorium	0. 056	0. 040	0. 012	0
Konsistorium, gross	0. 004	0. 003	0. 001	0
Natural Science Faculty Board	0	0. 002	0. 015	0. 057

$\underline{p}$: Earmarked portion of resources.
$\bar{x}$: Units allocated by Konsistorium.
$\bar{y}$: Units allocated by the Natural Science Faculty Board.

Figure IV.8.6.
DEVIATION MEASURES, CASE 1

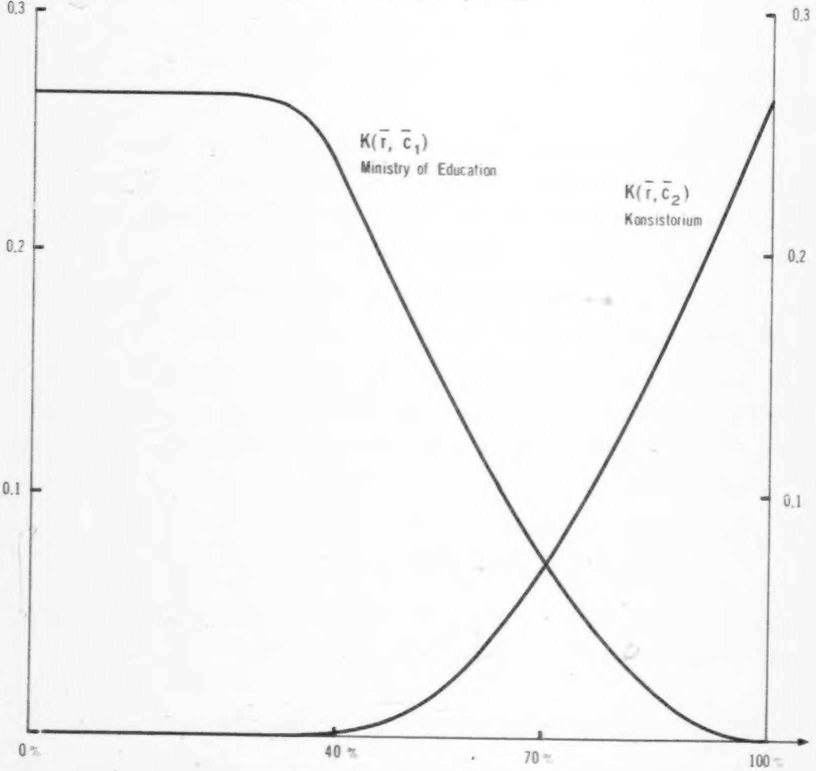
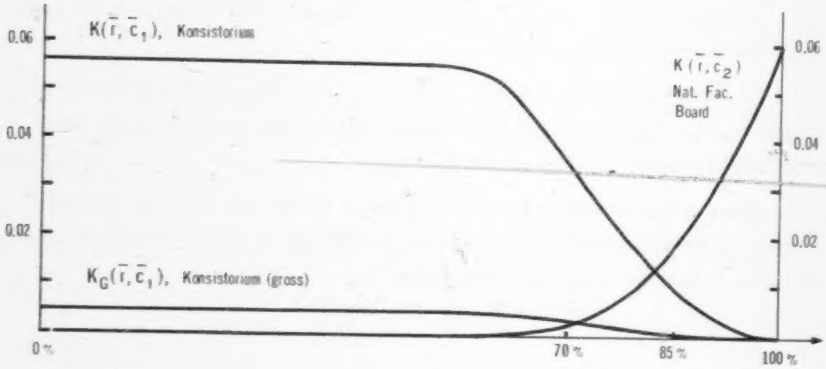


Figure IV.8.7.
DEVIATION MEASURES, CASE 2



We observe from Figures IV. 8. 6. and IV. 8. 7. that the earmarking of resources makes practically no difference as long as the earmarked portion is less than 40 % for case 1 and 65 % for case 2. Equal values of the deviation measures are assumed for an earmarked portion of 70 % for case 1 and 84 % for case 2.

These observations are consistent with the fact that the decisions makers agree upon the allocation of a certain portion of the resources, namely 40 % in case 1 and 65 % in case 2, and thus will be equally (dis-)satisfied if the remaining portion of resources is divided equally between them.

The deviation measures for case 1 are much larger than for case 2, due to the larger amount of conflict in case 1.

For case 2 the gross deviation measure for Konsistorium is shown for a grouping of the budget categories as shown in Figure IV. 8. 7. Since the major differences in preferences appear within the groups and not between the groups, the gross deviation measure must be quite small.

For both cases the approximation,

$$\sqrt{K(\bar{r}, \bar{c}_1)} + \sqrt{K(\bar{r}, \bar{c}_2)} = \text{constant},$$

holds very closely over the whole range of p-values, which might be expected since the applied deviation measures $K(\bar{r}, \bar{c})$ are quadratic.

Concluding remarks and suggestions for future research

The developed decision model is very primitive and should be used with great care as a decision basis if one wants to move decisions between managements with different objectives.

To make the model more realistic some of the following suggestions could be investigated in future research work :

The model could be extended to include a possibility for the first decision maker to utilize his knowledge about the second decision maker's preferences. This can be studied with the aid of game theory.

Other deviation measures may be used, e. g. the one used as objective function in the LP-model of H. J. Rasmusen, Chapter 7. In the notation for the deviation measures this would correspond to :

$$K(\bar{r}, \bar{c}) = \sum_{j=1}^{n} w_j \quad d(c_j - r_j)$$

Stochastic variables, e.g. student attendance numbers, could be included in the deviation measures and the minimizations could then be performed according to an expected value criterion.

Chapter 9

THE DEVELOPMENT OF A DECISION MAKING PROCESS

by

Hans Jørgen Rasmusen

Introduction

The purpose of this paper is to elaborate some of the major issues that must be considered when organizational innovations and new decision-making procedures are proposed.

The paper is initiated by a discussion of the differences between strategic and tactical planning. It continues with a discussion of resource flexibility and uncertainty and the implication of these factors on the planning. The issues of marginal versus total budgeting are briefly touched.

The paper continues with a discussion of performance criteria and the development of decision-making procedures based upon either the satisfaction of future expectations or on an evaluation of past achievements.

The results of these analyses are then synthesized into a proposal for a new and improved decision-making procedure, where the strategic and tactical planning is performed in two independent processes, only connected by the formulation of guidelines and the evaluation of consequences.

Neither the analyses nor the proposed budgeting procedures have been aimed towards the development of the ultimate happy decision-making structure. Indeed we have a strengthened feeling that no such structure does exist.

Faculty members and students are however continuously occupying two very different positions in the university. Sometimes they appear as innocent and helpless academicians, to whom the problems of the real world seem so complicated and difficult that they plead with the administrators to help solve the problems.

At other times they appear as determined, hard fighting politicians and managers using all the small dirty tricks of real life in the fight for society's resources and public prestige. Unfortunately it takes both skill and knowledge to ride two horses at the same time. Thus some definite improvements would be attained if everybody involved considered more carefully which horse they were going to ride.

Strategic versus tactic al planning

Most contemporary literature on planning distinguishes between two major kinds of planning. One is the strategic planning and the other is the tactical planning(1, 2).

Strategical planning deals with goal formulation, policy making and in general any issue affecting what an organization is doing, and the way in which it is doing it.

Tactical planning, on the other hand, is dealing with the current operation of the system or organization. The main purpose is to select the best possible set of current actions in order to reach the strategic goals sooner or later.

Although the two kinds of planning are complementary and interacting, one must know whether one is dealing with strategic or tactical planning, because tactical planning becomes erratic when no goals are formulated, and strategic planning tends to become frustrating if it is undertaken when tactical planning is demanded. During the course of our research project we learned that nobody in the university system has ever attempted to separate the two kinds of planning(3, 4)

Faculty members and students mainly deal with strategic planning in terms of establishing new courses and changing curriculae. These plans usually end up with a long list of required resources.

The administration on the other hand is almost always left alone when it allocates the operating budgets approved by the Ministry of Education. This division of work has over time led to quite a lot of dissatisfaction and frustration.

Much time has been spent by faculty members and students preparing and

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(1) Ackoff, Russel L., A Concept of Corporate Planning, Wiley-Interscience, 1970.

(2) Ansoff, H. Igor, Corporate Strategy, Penguin reprint, 1970.

(3) Jurkovich, Raymond, CERI Report VII, IMSOR 1970.

(4) Rasmusen, H.J., CERI Report XIV, IMSOR 1971.

working on ideas towards better teaching procedures and research work. However these plansare almost always developed without any consideration for either the likely availability of additional resources or the current supply of resources.

Financial and budgetary trained personnel never participate in the strategic planning, although they easily could supply much relevant information at a time when proposals could yet be modified.

When proposals are made in this way they tend to become very inflexible in terms of goals and resource requirements. This situation has specific relevance in one phase of the budgetary process, where each institute and department of the university is asked to make a budget proposal for the following four year period [Hammer-Jespersen and Halpern (1, 2)] .

These proposals were initially thought of as a general statement of goals and objectives, which the administration and top decision-making body could use when they made the resource allocation. The institutes and departments did however soon adopt a somewhat different point of view. To them the proposals became a statement of resource demands necessary to survive.

The strategic planning, resource wise and otherwise, in a university can obviously be greatly improved if the planning is performed with reasonable consideration for the likely demand for service (teaching) and the likely supply of resources.

Turning from the strategic planning, the tactical planning is the process by which the strategic goals are approached in the daily operation. It is necessary to know and understand the strategic goals in order to select a proper course of action. Those who do the tactical planning can do very little in terms of satisfying the strategic goals if they do not understand these goals.

It is generally not possible to satisfy all goals immediately, thus the satisfaction of some demands must be postponed to some future time periods. This difficult job is left to the administration of the university. Few faculty members and students have been particularly eager to participate in this job, because it necessarily must involve some priorities, which the faculty members and students have tried to escape in the strategic planning.

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(1) Hammer-Jespersen, Chapter 3.

(2) Halpern, Jonathan, CERI Report XII, IMSOR 1970.

One thing which troubles the tactical planning is the fact that it generally only deals with marginal resource allocations. A marginal resource allocation procedure is only permissible if one can assume that the system initially is in an optimal state, and that this state can be sustained by future marginal allocations.

Another main trouble in the tactical planning is the lack of relevant information. Planning always has to be done under states of more or less uncertainty as to the future and on incomplete data. As a consequence the planning techniques applied must be designed to overcome these deficiencies of the real world.

The tactical planning in a university can in general be improved if faculty members and students, rather than complaining over a general lack of resources, would participate more directly in the distribution of those resources actually available. Participation however does not in itself solve all problems. It is just as necessary to ensure that all parties involved are informed and hopefully also understand how the resources have been divided and which criteria have been applied.

The main purpose of this paper is to analyse and suggest how the strategic planning and particularly the tactical planning can be organized.

Resource flexibility and uncertainty

The educational system is dealing with three major types of resources.

1) Operating money
2) Tenure manpower positions
3) Physical facilities.

These major types of resources exhibit very different properties in terms of flexibility in use and substitution.

Low flexibility of resources means that once a particular resource is allocated to a specific task it is impossible, or at least difficult, to transfer it to another task. Low resource flexibility becomes important when resources are to be allocated to activities which only have a finite expected lifetime, because the activity might become obsolete earlier than the time at which the particular type of resource can be released and reassigned to a new job.

When such situations occur resources are trapped in the organization. That is, the organization could either supply the same amount of service at a lower total cost or it could provide more service at the present level of costs or use of resources

All activities become obsolete sooner or later, but the uncertainty of the future demand is higher for some activities than for others. Decision-makers have always recognized this fact and designed their organizations in ways which expected the waste of resources to be as little as possible.

The risk a decision-maker is facing is a combination of the future uncertainty of the demands and the flexibility of the resources required to satisfy the demands. The higher the uncertainty of the future becomes and the lower the flexibility of the resources becomes, the higher is the risk that the decision-maker in the future will find that resources are wasted, trapped by activities no longer of much relevance, If he embarks on the project.

Public systems have only very seldom applied quantitative risk and uncertainty analysis techniques to resource allocation problems. Instead the risk evaluation has been performed by a centralized political process in which the politicians have decided whether they believed or judged the activity to be worthy or not.

A political decision obviously does not change the uncertainty, but changes the attitude towards the activity. The activity is no longer a consequence of a demand for some kind of service, but a mere result of a political decision.

Centralizing decision-making thus has two main implications. In terms of resource allocations the central decision-maker assumes that he, because he knows the goals better and in general possesses more relevant information, is able to allocate resources in ways best satisfying future demand with due consideration to uncertainty and inflexibility of resources.

An organizational aspect of centralization is that the responsibility is taken away from the people who work on the project If the project fails or if the project is seriously criticized by others, the employees never have to validate the activities themselves. They can always excuse the project by saying that somebody of more influence has found it worthwhile to undertake, a situation in which the employee earns a considerable amount of protection.

Although this explanation is highly idealized it serves the purpose to show that centralization may be an annoyance to the strong and active members of an organization. However centralization often turns out to be a good protection of the weak members.

A key issue in the discussions on organizational developments and introduction of modern planning techniques in a university system is dealing with the ultimate requirement that the academic freedom must be preserved or even expanded. These requirements must necessarily be seen in the light of the general lack of sufficient resources and the continuous possibilities that the future might turn out differently from what currently is expected.

One of the most pronounced benefits earned by belonging to an organization rather than acting as an independent is the ability of the organization to absorb much more risk than its members are able to do as individuals. This ability is partly due to the existence of organizational slack(1) and partly to the fact that it is highly unlikely that all activities fail at the same time.

Once individuals have joined together and formed an organization, the organization establishes a set of rules in order to minimize the risk exposure. The prime purpose of these rules is to secure that no single member can ruin the future existence of the organization, deliberately or by accident.

The larger an organization the more complicated are the rules. However the purpose continues to be an attempt to minimize the economic and possible moral liability of the individuals, as well as an attempt to insure the future existence of the organization as a unity.

An organization does not only protect itself by issuing a set of rules and procedures, it also attempts to coordinate the activities of its members as much as possible, thereby trying to economize the use of resources.

When the central coordination has to be avoided because it is violating the autonomy policy, it obviously becomes very expensive to maintain the risk absorption at the central level, i. e. the requirement that the central level must cover the cost of whatever activity it suits the members to engage in. This would not lead to too much of a problem if the resources employed in the university system were highly flexible and elastic. Unfortunately this is not quite the case.

Rather than reducing the autonomy of the institutes of a university we will propose that the risk should be absorbed by the autonomous units themselves. In short it means that an institute must live with the decisions it has made, and that it is up to the institute itself to ensure that the available resources are allocated where most appropriate.

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(1) Cyert and March, A Behavioral Theory of the Firm, Prentice-Hall, 1963.

A central decision-maker, whether an individual or a society, is seldom interested in engaging in a decentralization process, if he believes this will lead to serious violations of the overall objectives of the part of the system for which he is responsible.

If decentralization has to be introduced, it is necessary to design the decision-making process and the constraints that must be satisfied in such a way that the organization is still able to carry out its objectives.

The inflexibilities of the resources used in the educational system are partly caused by technical reasons and partly by organizational reasons. This separation implies that some resources or assets only can be used for one or a few different jobs, and that it is beyond the control of any human being to change this. Physical facilities have to be used where they happen to be located. The current state of the construction art does not permit us to move buildings around. Other resources show a limited use as a result of organizational tradition and work agreements. This is particularly pronounced with the human resources.

The budgeting system itself introduces a good deal of inflexibility. Being a marginal system all current activities, also those obsolete, are permitted to roll along. It is very seldom that negative marginals have appeared in budgetary proposals. By and large all major improvements in resource flexibility must be attained through improved personnel policies.

The tenure manpower positions are inflexible in use mainly because of work traditions. This is particularly true with the tenure academic positions. The academic freedom, job security etc. make it more or less impossible to move people around, if changing demands should suggest that this would be a desirable action. It is beyond the scope of this paper to discuss whether this policy is reasonable or not. We would only emphasize that in times with rapidly changing demands(as will be the case in a university based upon elective subjects only), a large amount of the total manpower resources must be expected to be allocated to subjects having little or no teaching demand.

The average lifetime of academics in tenure positions varies from one part of the university to another. Those areas which have an effective labor market outside the university show average lifetime around 5 years, versus areas like the Philosophy Faculty, which shows lifetimes averaging 20 - 25 years.

Total versus marginal budgeting

We have several times in the past two sections criticized the current marginal budgeting procedures. It may however be profitable to elaborate a little more on the total-marginal budgeting problem.

It is generally claimed that an application of a total budgeting system (sometimes called zero-budgeting) leads to a better overall resource allocation and hence to a better overall composition of activities ; because not only all planned but also all current (status quo) activities together with all available resources are considered simultaneously.

A consequence of a total budgeting system is that all obsolete activities are terminated as soon as possible. An intention to end all out-of-date activities improves the resource flexibility, which in turn means that the risk for a long-term misplacement of resources is reduced. A total budgeting system operates equally well when the organization using the procedure is growing or is in a stable situation.

The negative sides of a total budgeting system are primarily that a very large and complex data gathering and data processing system is required if all plans, current and proposed, have to be documented to the same degree as in the present marginal budgeting system. This calamity can be overcome by the introduction of a decentralized planning system(1).

Another, maybe less pronounced,feature of a total budgeting system is that it becomes more difficult to maintain activities which are incongruent with the overall objectives of the organization. This of course does not mean that conflicts do not exist in a total budgeting system, quite the contrary. These conflicts however must be recognized and included in the planning.

The main feature of a marginal (partial) budgeting system is that only the newly proposed activities are considered in the planning process. A decision-maker who only deals with marginal allocations is, however implicity, assuming that all decisions and resulting resource allocations made in the past are still relevant and optimal.

This may be true in a stable or slow growing society. It is however not likely to be the case in a very dynamic system, like that of a modern university.

The fact that a decision-maker approves a few well documented plans obviously does not guarantee that the vast amount of resources already granted in previous years are being used effectively. It is much more likely that the proposals only cover safe and high priority issues, with some of the more dubious projects well hidden in the basic budgets. It may look as if a marginal budgeting system gives more latitude to those who spend the resources than a total budgeting system does. This issue is however entirely a matter of how a decentralized procedure is designed.

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(1) Rasmusen, H. J, Chapter 7.

Performance criteria

Whenever total budgeting procedures are proposed, there is always someone who claims that it is impossible to apply such a procedure because the activities of a university are multi-dimensional, not measurable on one common scale.

This point obviously holds equally well in the case of a marginal budgeting system. Both budgeting procedures require a set of performance criteria in the evaluation process.

A performance criterion is a managerial tool evaluating and assigning a value to one or a set of activities as an output. Typical performance criteria in a university are student/teacher ratios, space per student or per teacher, ratios of teachers' time spent on teaching and research, tenure to non-tenure teacher ratios etc.

Performance criteria are used in place of a more general value function and their main features are that they usually are defined or constructed in order to simplify the measurement and application.

Each performance criterion usually has a critical value associated with it. The critical values may be interpreted as goal values, which one tries to reach through the allocation of resources.

In cases where more than one performance criterion is used, these criteria are ranked according to their priority, so that high priority criteria are satisfied first.

If the system can be modelled as a linear system, then the goal-programming approach devised by Charnes and Cooper(1) can be used as a model.

Although performance criteria are developed in order to escape the development of a complicated common objective function, one must be particularly careful when the critical values are determined or agreed upon, because these numbers may easily be so fixed that no planning solution can be found at all, that is, that the objectives lead to an unfeasible system.

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(1) Charnes, A. and Cooper, W. W., Management Models and Industrial Applications of Linear Programming, Wiley, New-York, 1961.

Performance criteria are by nature an average measure of one activity in one administrative unit. Hence if one unit is subdivided into subunits, one cannot expect that the values of the performance criteria calculated for each subunit equal the value calculated for the main unit; rather one must expect to find some subunits with values larger than the average and some with values smaller than the average.

Decision rules

Once the general objectives and the performance criteria for an organization have been agreed upon one can start to consider the issue of determining appropriate decision rules.

The purpose of a decision rule is to define a set of activities or courses of action which the administrators and planners can apply in the tactical planning. Two key issues must be considered when a tactical decision rule is developed in order to secure operationability. It must first of all be congruent with the strategic planning and it must account for the resource flexibility. From the point of view of implementation, a decision rule must further be of a simple structure in order to permit a simple evaluation.

A decision rule can broadly speaking be based upon either the future expected performance or upon the recorded past performance. A third but far more complicated group of decision rules can be developed by combining both the future expectations and the past performances. Such rules are said to have learning abilities or to be adaptive rules. However because of the high degree of complexity they are beyond the scope of this paper.

Decision making based upon future expected demands and activities

The general idea behind all planning is that among a vast number of possible courses of action only one or a few will satisfy the future expectations. Thus in order to engage in planning, one must be able to make a reasonably good estimate of the future demands for an activity, and one must be able to devise the means by which the demands can be satisfied.

If it is impossible to make any evaluations of the likely future demands there is no point in using the future as the basis for planning. In such cases it may be considered safer to use the past achievements as the planning basis. This issue brings us back to the issues of resource flexibility and strategic planning.

With an open-door policy for the universities(1) it is literally impossible to make a central forecast of the specific curriculae demands, because one just does not know what the students are going to choose. This difficulty is further increased because individual teachers or departments can initiate campaigns or other "public relations" activities in order to attract students.

Experience does on the other hand show that it is possible, at least in Denmark, to estimate the new enrolments into the faculties very accurately. The high degree of accuracy is partly due to the fact that the behavioral patterns only undergo small changes from one year to another and partly because students must satisfy certain general enrolment criterias, which usually requires several years of prior education.

Thus because - given some general policies - from a certain level upwards, it is possible to estimate future demands, it is also possible to plan the resource allocations which will meet the demands in the best way. If we assume that the general educational policy at some time was changed from an input oriented policy to an output oriented policy, this would result in a completely different planning situation.

The most obvious advantage of applying a planning procedure is that it will permit the selection of the best current decision, giving some consideration to the future demands. It is further possible to design multi-year planning procedures so that they are able to consider resources of various degrees of flexibility.

General resource limitations can also be incorporated in the planning models, both in cases where the limitations cover a shorter and a longer period of time.

The main disadvantage of all planning procedures based on future expectations are their high sensitivity towards bias. Bias is a systematic over- or underestimation, of for example demand or supply, which has the result that wrong plans are selected as the best.

Bias is not necessarily a result of deliberate misinformation, it may simply be the result of too much pessimism or optimism. Bias should naturally be avoided because in the long run it will result in a wrong allocation of resources.

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(1) This policy does not cover certain professional schools, who have enrolment ceilings.

This is particularly the case with resources like physical facilities, which must be ordered and designed one or more years before they can be activated by the system.

Detailed descriptions of applicable planning techniques are given by Hammer-Jespersen and Rasmusen in this report.

Decision-making based upon past achievements

When a system is so organized that each member has a high degree of autonomy, it becomes literally impossible to perform any central coordination or control function. Such a situation is likely to emerge at the institute and course levels of a university. At this level the autonomy means that the institutes have a large amount of latitude in the selection of research topics and the students have a high degree of influence upon the courses offered.

The introduction of a planning scheme which attempts to anticipate future demands will result in a much too restricted system. The limitations on the available amount of resources still however exist, and particularly the resource inflexibility still introduces limits, which in many cases seriously may reduce the autonomy of the involved parties.

How can such a system be designed and which are the constraints ?

Arne Jensen suggested the introduction of a payment system. The introduction of a "payment" system will effectively link the total amount of resources allocated to an autonomous unit to the achievements of the same unit, measured in terms of a performance criteria. Thus if the achievements are larger than those which correspond to the critical value of the performance criteria, more resources are allocated to the unit, and if the achievements are too low, resources are taken away from the unit as soon as possible.

In terms of data collection and data processing this means that the problem of forecasting future demands is reduced to a registration of achievements in the most recent time period ; thus rather than requiring a forecasting system one requires an auditing system.

Unfortunately there has not been sufficient data for studying the natural variations in the system in practice. Epidemic movements of students desires might severely influence the possibility of carrying through a reasonable staff policy.

Seen from the point of view of the autonomous institutes any planned activity must be evaluated as a risky investment decision. The resources necessary to initiate an activity must be supplied by the institute itself, for instance by temporary reduction of the research activity. If the new activity turns out to attract students, credit will be given at a subsequent evaluation of achievements. If however the activity fails to attract any students, the investment, in terms of preparation and lost research time, is lost and no credit is granted.

A salient feature of this decision rule is that resources are allocated to those who try to satisfy the market demand. However a very relevant question is what happens to the people who are no longer able to supply any teaching demand ? An answer to this question depends upon the general personnel policies of the organization.

If it is possible to hire qualified personnel constantly and without delay, and if it is possible to lay-off personnel as soon as excess capacity occurs, then the above mentioned decision rule can be implemented easily. University organizations have however adopted personnel policies that generally guarantee once-hired persons a high job-security, thus creating severe limits in flexibility in areas where the average service time of the employee is larger.

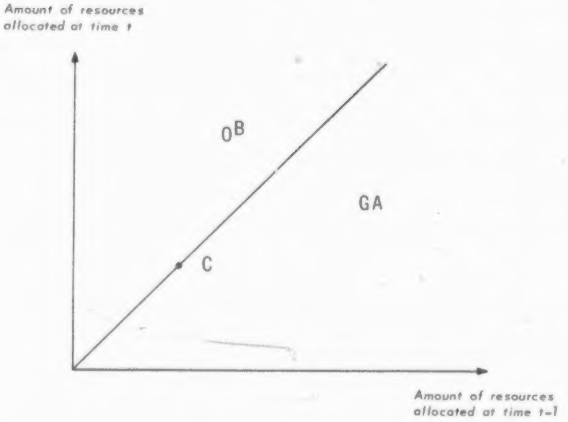
The application of the "payment" resource allocation is initiated by a computation of the proper value of the critical value of the performance criteria. This step is necessary because there might be a general lack of resources. A centrally solved model determines the total amount of resources that can be expected to be available for each faculty. Each faculty further knows the achievement of,for example,teaching in the most recent time period, both in terms of a total value and of the distribution of achievements in each institute of which the faculty is composed.

The second step is to make an ideal resource allocation corresponding to the achievements. This allocation is ideal because it assumes full resource flexibility. The allocations of two consecutive years can be illustrated by a simple graph (Figure IV. 9. 1).

The sloping line divides the area into two parts. Any point (like B) lying above the line is a candidate for more resources, versus any point below the line (like A) that must give up resources. Points on the line (like C) are status quo, their resource quantas are neither increased nor reduced.

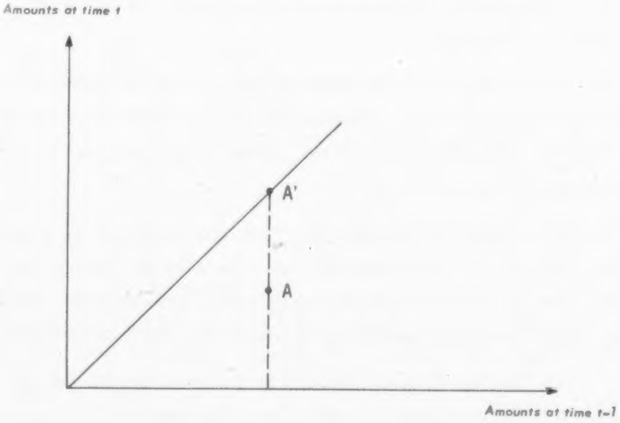
The location of each institute in the area can now be determined by plotting the actual resource allocation for time period t-1 along the horizontal axis and the computed (ideal) allocation along the vertical axis (Figure IV. 9. 2).

Figure IV. 9.1


Amount of resources allocated at time t
OB
GA
C
Amount of resources allocated at time t-1

Unfortunately not all types of resources can be transferred from institutes located below the break-even line to institutes located above the line, only a certain amount of the excess capacity can be expected to be released during the time period t.

Figure IV. 9. 2


Amounts at time t
A'
A
Amounts at time t-1

If it is impossible to reallocate resources, then any point below the line is unattainable. Instead of reaching point A, point A' is reached. In general a point somewhere between A and A' can be reached.

Several different approaches may be taken in order to reallocate the available resources.

All institutes demanding resources can be ranked according to the size of their demand, and we can then start to satisfy the demands from the top-end. This decision rule will give high priority to large demands and low priority to small incremental demands.

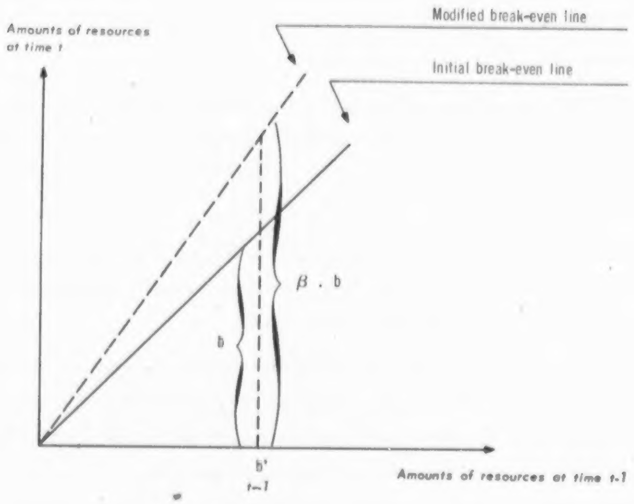
Another approach is that all demands for additional resources are reduced by a proportion equal to the ratio between the total available amount of resources and the total demand for additional resources.

The first approach has the clear advantage that it recognizes the fact that the only way in which an institute can increase its teaching output, when the numbers of employees are constant,is by an equal reduction of the research activity. Thus the larger the increase in teaching output, the lower is the research output, and the longer such a situation prevails the more unsatisfactory are the working conditions.

The second approach looks fairer because all who need resources must suffer by the same proportion, that is, everybody gets something. However one must in general expect that a good deal of the total available resources is allocated to institutes who only require small increases in their resources; thus from a total point of view the second rule favors slow-growing institutes.

In order to improve the situation for the rapid growing institutes a third approach may be designed. A popular explanation of this rule is that the breakeven line is tilted upwards so that fewer demands-points remain above the line (Figure IV. 9. 3).

Figure IV. 9. 3


Modified break-even line
Amounts of resources at time t
Initial break-even line
β . b
b
b'
t-1
Amounts of resources at time t-1

A Mathematical Treatment of a Payment System

The proper inflexibility correction factor can be determined by solving a set of mathematical equations.

Assume that p^i_{t-1} designates the performance of the i-te institute, in the most recent time period (t - 1), and that CF_t is a number that transforms the performance unit to a portion of resources, that is $CF_t = \frac{1}{\sum_i p^i_{t-1}}$

The total resource allocation to the i-te institute then becomes,

$b^i_t = B_t \cdot CF_t \cdot p^i_{t-1}$ where B_t

is the total available amount of resources

$$B_t = \sum_i b^i_t$$

The marginal resource allocation now becomes

$b^i_t - b^i_{t-1}$ of which some are positive, some negative or zero.

Assuming full resource flexibility we obtain

$$B'_t = A'_t$$

$$B'_t = \sum_i (b_t^i - b_{t-1}^i) \text{ for all positive differences.}$$

$$A'_t = \sum_i (b_t^i - b_{t-1}^i) \text{ for all negative differences.}$$

If full resource flexibility does not exist and α designates the proportion that may be released in one time period, one obtains

$$B''_t = \alpha \cdot A'_t \quad , \quad B''_t < B'_t$$

Since B''_t is less than B'_t, not all institutes having positive marginal can have their demands filled.

The first proposed decision rule in which the largest marginal demand is filled first is thus equal to a ranking of all positive values of $b_t^i - b_{t-1}^i$ according to size, and a subsequent allocation of resources until

$$\sum \left(b_t^i - b_{t-1}^i\right) \text{ becomes equal to } B''_t = \alpha \cdot A'_t$$

The remaining institutes for which the marginal is positive do not obtain any marginal allocation.

The second decision rule in which everybody gets a proportionate share is equal to a marginal allocation of

$$\alpha \cdot (b_t^i - b_{t-1}^i) \quad , \text{ for } (b_t^i - b_{t-1}^i) > 0$$

The third decision rule in which the break-even line is tilted upwards is equal to an artificial increase of last years resource allocations(1), that is, a factor β is introduced so that

$$B_t^* = \sum (b_t^i - \beta\, b_{t-1}^i) \text{ for all } b_t^i - \beta\, b_{t-1}^i > 0$$

$$A_t^* = \sum \begin{Bmatrix} b_{t-1}^i - \alpha\, b_{t-1}^i & \text{if } \alpha\, b_{t-1}^i > b_t^i < b_{t-1}^i \\ b_{t-1}^i - b_t^i & \text{if } \alpha\, b_{t-1}^i < b_t^i < b_{t-1}^i \end{Bmatrix} \quad \begin{matrix} \text{for all} \\ b_t^i - \beta\, b_{t-1}^i < 0 \end{matrix}$$

Since B_t^* must equal A_t^* one value of $\beta > 1$ can be determined for which this is true.

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(1) or less credit is given for last years performances.

β is equal to 1 when α is 1 and it reaches a value equal to max $\left(\frac{b_t^i}{b_{t-1}^i}\right)$ when $a = 0$, i. e. when no resources can be released.

The third decision rule will lead to a modified total resource allocation, which is equal to

$$b_t'^i = b_t^i - b_{t-1}^i\,(\beta - 1) \quad \text{for all}$$

institutes for which $b_t^i - \beta\, b_{t-1}^i \geq 0$; for the remaining

institutes for which $b_t^i - \beta\, b_{t-1}^i$ is less than 0

the new total resource allocation becomes

$$b_t'^i = \begin{cases} \alpha\, b_{t-1}^i & \text{if } \alpha\, b_{t-1}^i > b_t^i < b_{t-1}^i \\ b_t^i & \text{if } \alpha\, b_{t-1}^i < b_t^i < b_{t-1}^i \\ b_{t-1}^i & \text{if } \beta\, b_{t-1}^i > b_t^i > b_{t-1}^i \end{cases}$$

The computation of the modified total resource allocation can in all cases be accomplished when each institute knows the following items :

The total available budget	B_t
The total achievements last year	$\sum_i p_{t-1}^i$
Last year's budget	b_{t-1}^i
Last year's achievements	p_{t-1}^i
The resource release factor	α
The resource inflexibility (scarcity) factor	β

Some possible consequences of applying a payment system

Although the implementation of a payment system, as a basic decision rule for resource allocation to units of an organization which are more or less autonomous, can result in a great improvement of the administrative procedures, there are at least a few organizational implications that must be considered.

The first implication is that a resource allocation rule based on past achievements renders it impossible for a subunit to approach the central decision-maker and demand special treatment, because one thing or another is turning out less profitable.

The fact that each subunit uses its own preference or objective function when planning makes it impossible to argue in terms of this when negotiating with the central decision-maker.

Thus if the leaders of the subunits turn out in general to have a high risk-aversion it must be expected to be difficult to implement the decision rule.

The second implication is that a system which allocates resources based on the achievements of a single period may lend itself to quite a good deal of gaming between the subunits, particularly immediately after the implementation.

The policy an institute may apply is to largely expand the teaching activities in one year, thereby securing a large increase in resources, followed by several years of very low teaching activities, in which the personnel can engage in activities of higher personal interest. The lower the resource flexibility is, the longer can resources be trapped in the system.

One way to overcome this calamity, at least to some degree, would be to base the resource allocation on a weighted average of the performances over a couple of time periods, rather than on the performance in a single period.

The high degree of simplicity of the "payment" decision rules, compared to planning models based on simulation or mathematical programming, leads to the question whether or not the payment decision rules could be applied more generally, particularly at higher decision levels.

A full appreciation of this question is beyond the scope of this paper. It must however be emphasized that a payment decision rule in a larger context has three main deficiencies.

First of all it is impossible to use the decision rule to compute the proper resource ceilings for each of the main sectors of which the organization is composed. This inability is partly due to the fact that the total amount of resources is limited and partly to the fact that the payment decision rule assumes that the available resources can be put into operation readily and without any delay.

The second deficiency is the fact that the payment decision rule assumes that resources are employed in constant proportions. It is thus impossible to substitute one type of resources for another.

Thirdly is a large scale application of a payment decision rule actually the adoption of a laissez-faire policy? The full consequence of this policy is that no scarcity exists at all. A laissez-faire policy may however be good enough if the area for which it is employed can be isolated from other areas and proper overall limits for its activities can be established by other means.

An improved decision-making procedure

The purpose of this section is to describe how the analyses of the previous sections can be utilized in the design of a more appropriate decision-making procedure.

Figure IV. 9. 4 is a schematic chart of the current budgetary decision making process. One notices that approximately one and a half years elapse from the time when an institute calculates its demands till the resources are available.

This delay causes several difficulties, as the budgetary period is one year long and the cycle is one and a half years long. Around December - January each year the institutes are initiating one planning cycle and at the same time making final adjustments in the plan from the previous planning cycle.

Working on two sets of plans at the same time requires a good deal of managerial expertise, which most institutes lack.

One of the objectives in the design of a new system should thus be to reduce the time delay at the lowest level of the budgetary hierarchy. Other objectives are to separate the strategic and the tactical planning phases and to apply a total budgeting procedure to the extent it is possible, as well as to make as much use as possible of all information available in the rolling four year budgets and resource ceilings.

Figure IV. 9. 5 shows how the proposed budgetary procedure works. The most pronounced difference between this procedure and the one currently being applied is that the initial semi-strategic planning at the university level is removed from the tactical resource planning and budgeting process. In fact the strategic planning is assumed to take place continuously and independent of the tactical planning, but of course connected to the latter kind of planning through the specification on guide lines etc.

The budgetary process is initiated in February each calender year by an "opening bid" from the Ministry of Finance, specifying resource ceilings

Figure IV. 9. 4

CURRENT BUDGETARY PROCEDURE

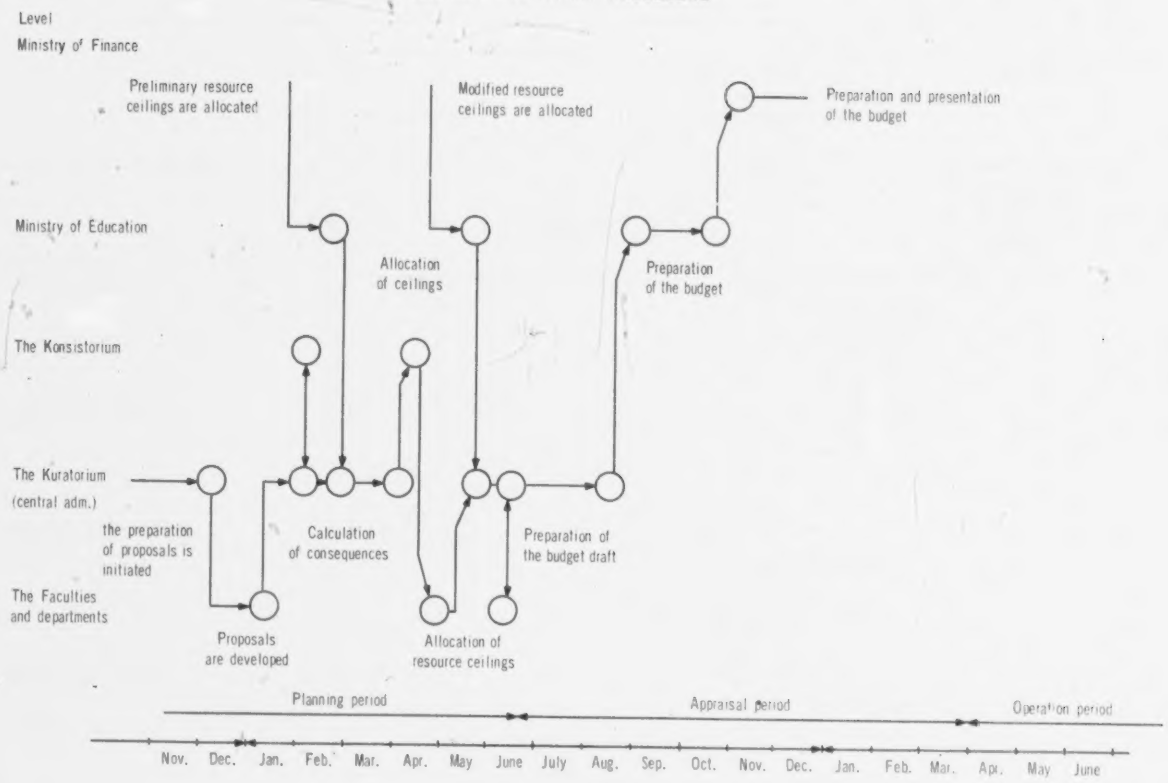
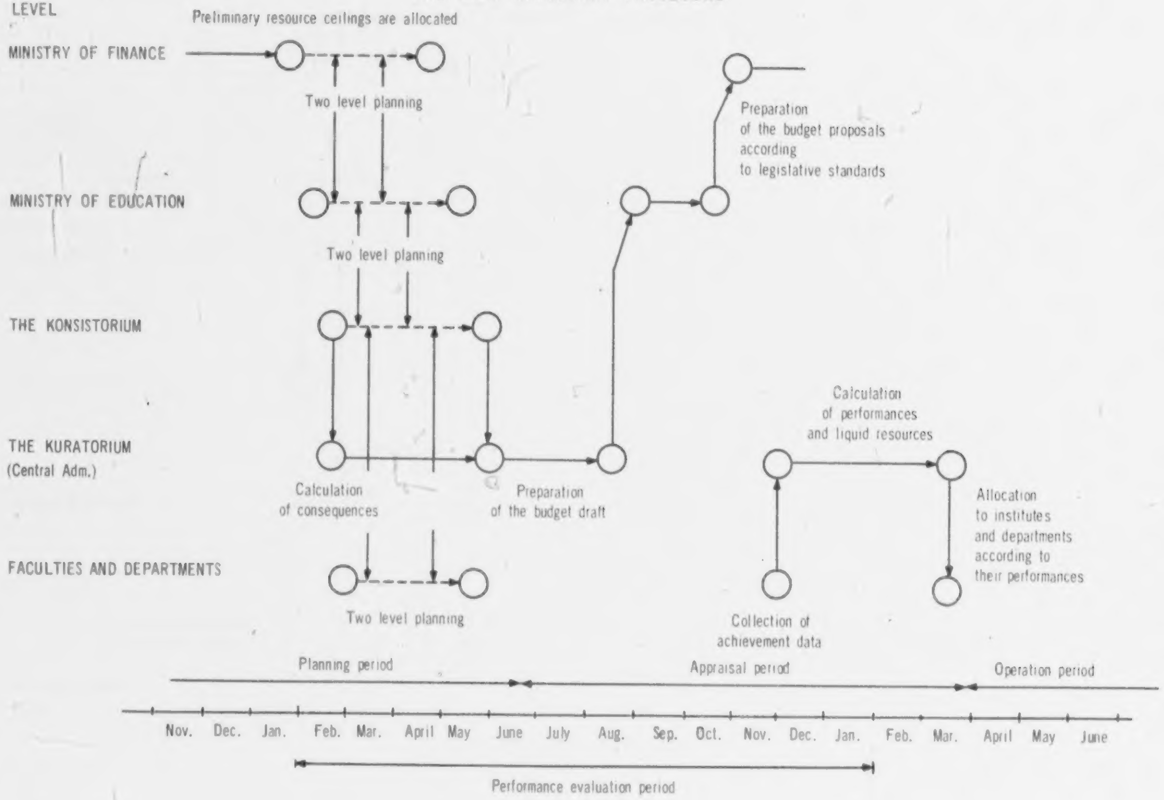

Level
Ministry of Finance
Preliminary resource ceilings are allocated
Modified resource ceilings are allocated
Preparation and presentation of the budget
Ministry of Education
Allocation of ceilings
Preparation of the budget
The Konsistorium
The Kuratorium (central adm.)
the preparation of proposals is initiated
Calculation of consequences
Preparation of the budget draft
The Faculties and departments
Proposals are developed
Allocation of resource ceilings
Planning period
Appraisal period
Operation period
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June

Figure IV. 9. 5

PROPOSED BUDGETARY PROCEDURE


LEVEL
Preliminary resource ceilings are allocated
MINISTRY OF FINANCE
Two level planning
MINISTRY OF EDUCATION
Two level planning
THE KONSISTORIUM
THE KURATORIUM
(Central Adm.)
Calculation
of consequences
Preparation
of the budget draft
FACULTIES AND DEPARTMENTS
Two level planning
Preparation
of the budget proposals
according
to legislative standards
Calculation
of performances
and liquid resources
Allocation
to institutes
and departments
according to
their performances
Collection of
achievement data
Planning period
Appraisal period
Operation period
Nov. Dec. Jan. Feb. Mar. April May June July Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. April May June
Performance evaluation period

for the fiscal year beginning April 1st the next year, and the following three fiscal years. As can be seen by comparing Figures IV. 9. 4 and IV. 9. 5 this is an extension of the current practice.

As soon as the Ministry of Education has received the total resource ceilings for the university sector it initiates a similar procedure of computing "opening bids" for the resource allocations to the different universities also covering a four year period.

Finally sometime in the month of March or April each university in turn performs a completely identical preliminary resource allocation to the sectors of which the university is composed.

The tool to be applied at each level can be a resource allocation model as the decentralized resource allocation procedure described by Rasmusen (1). Each decision level estimates forecasts for the demand for service in terms of sector totals. It is essential that a total budgeting procedure is applied.

Through the months from April to the end of June the three above mentioned decision levels engage in a series of budget modifications and modifications of resource ceilings. This process is eased by the application of information contained in the shadow prices corresponding to the scarce resources, that is, the reallocation goes on until a state has been reached in which the shadow prices are approximately equal in all sectors. This state is called the optimal state and the resource allocations the optimal total resource allocation.

From approximately July to October the computed plans are translated into the standard formats employed by the legislation and by the end of October the plans are ready for presentation in the parliament, which is a statement of the amount of resources proposed for each budgetary sector and unit.

From November and until April the subsequent year the budget proposal may undergo modifications in order to incorporate amendments from members of the parliament.

It is noticed that the determination of the optimal resource ceilings takes place without much involvement from the decision-making units inside the university. This is because the process in this phase has to do with ceilings and totals and not with specific programs or ideas.

However when the top decision-making body of the university (the Konsistorium) solves its decentral resource allocation model, it must necessarily know quite a good deal of what the institutes of each faculty expect to do in the future, in order to know the technical coefficients describing each faculty. This knowledge is transmitted to the Konsistorium by the representatives from each of the faculties, during the course of the determination of the ceilings.

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(1) Chapter 7.

The decision-making rule to be applied at the three above mentioned decision levels is based upon future expected demands. As it has been emphasized earlier this decision rule is insufficient inside the faculties of the university because of the rapid changes in the popularity of the subjects and courses. At this decision level a decision rule based on past achievements is recommended.

The reference period is a two semester period, a spring and a fall semester as shown in Figure IV. 9. 5. from February to February. The performance or achievements in terms of the objective function, for example teaching, in this period is the basis upon which the resource allocation for the subsequent fiscal year is determined.

If it is assumed that the work load over a semester is reasonably constant, then the performance measure for each institute can be estimated already around October. The total amount of resources for the faculty to which an institute belongs is also known with a relatively high degree of certainty at the same time.

Assuming that the general resource flexibility is known for the faculty, each institute can now apply the payment allocation rule and estimate the likely size of its supply of resources for the subsequent fiscal year.

During these five or six months the institute can plan the courses it wants to offer in the coming semesters as well as the proper staffing.

This reduction of lead time is a reduction of approximately 1 : 3 compared to the current procedure, thus it must be assumed that better planning and less dissatisfaction is a result. The payment allocation rule and the evaluation procedures permit the institutes and its employees to estimate the immediate future with a high degree of certainty and confidence, a feature completely missing in the current planning and budgeting procedure.

When the reference period is closed by the end of December, the central administration or another administrative body performs a computation of the actual performances of the institutes. In the months of January and February the administration applies the payment allocation rule in the allocation of resources to the institutes.

Since part of the resources to be allocated are assumed to be released during the course of the fiscal year, only the marginal increase is available at the beginning of April. This calamity is overcome by the establishment of a priority list of those who are going to receive resources during the fiscal year, as well as the amounts they are allocated. Thus part of the demand is filled initially and part as resources are released.

By the end of February the faculties should be able to publish a list of the achievements of the past reference period as well as a statement of the total amounts of resources allocated to each institute and department.

This statement should preferably include a brief statement of the general flexibility of resources as well as the development in supply and demand for teaching. The main purpose of these statements is to ensure that every involved party is informed about the ways in which the final allocations have been determined as well as the situation in general.

A flow chart of the decision-making process at the Konsistorium level is given in Figure IV. 9. 6. This chart also explains how the planning model is revised during the process.

The exchange of information

When the strategic planning and the tactical planning have to be performed by different people and at different times one is naturally led to the question how is information exchanged between the two processes ?

One is easily led to the conclusion that one of the reasons for the current frustration is that wrong information is available at wrong times. Many writers on strategic planning emphasize the necessity for written strategic goal formulation as a means to inform others about a decision-makers attitudes and intentions. The resource requirement proposals made by the institutes as an initiation of the current budgetary process contain many of the above mentioned properties, yet they fail to work as intended, because no information is fed back.

An improved tactical planning (not decision) procedure is a good start for an improved flow of information. Figure IV. 9. 6 is a schematic plan on how information relating to resource allocations may be disseminated inside the university in connection with the tactical resource planning. The process is expected to be repeated annually beginning in the month of April, when the first (tentative) resource ceilings have been received from the Ministry of Education.

As soon as the central administration of the university has received the tentative resource ceilings it solves the planning model, using the new demand forecasts. The technical coefficients of the model are those used in the last solution of the previous year.

The resulting plan as well as the assumptions,the ceilings and the demand forecasts are presented to the top decision-making body of the university (Konsistorium). The shadow prices computed are returned to the Ministry of Education for their further planning.

When the Konsistorium reviews the initial plan some or more members must be expected to have points of serious criticism.

The next evolution step is a careful analysis of the points of criticism and dissatisfaction. Some of the forecasts might be considered to be too pessimistic or optimistic, some of the technical coefficients of the model may require adjustments, even the planning objective may require an adjustment. In any case the revision process involves the administration as well as one or more members of committees, deans of faculties etc. In order to gather information and to understand the arguments, the planner must meet face to face with the parties involved.

Formal written communication is of little value as long as the main activity is to search for a feasible solution.

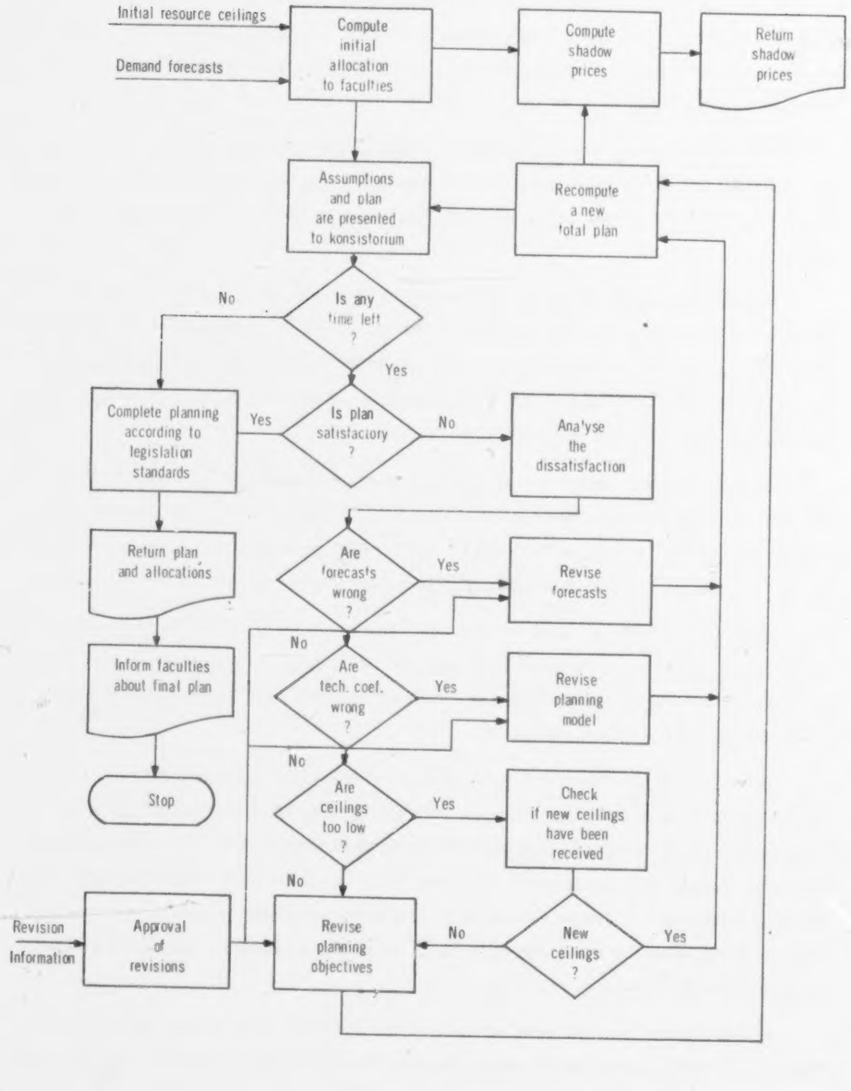
Every time ceilings, assumptions, forecasts etc. have been modified or revised the planning model is solved all over again and the Konsistorium is called for a new meeting and possibly a new revision.

The planning procedures developed during this research project are operating so fast on a modern computer that many revisions may be made during the course of a meeting or when the Konsistorium breaks for coffee.

The members of the Konsistorium are all faculty members and students belonging to the various institutes and departments,thus a result of a meeting is that information is spread. Not only does a representative from one faculty know how his faculty is affected, but he does in fact also have access to information on how all the remaining faculties are operating and he has a good standard for

Figure IV.9.6

MAJOR STEPS IN THE PROPOSED TWO-LEVEL RESOURCE ALLOCATION PROCEDURE


Initial resource ceilings
Demand forecasts
Compute initial allocation to faculties
Compute shadow prices
Return shadow prices
Assumptions and plan are presented to konsistorium
Recompute a new total plan
Is any time left ?
No
Yes
Complete planning according to legislation standards
Yes
Is plan satisfactory ?
No
Analyse the dissatisfaction
Return plan and allocations
Are forecasts wrong ?
Yes
Revise forecasts
No
Inform faculties about final plan
Are tech. coef. wrong ?
Yes
Revise planning model
No
Stop
Are ceilings too low ?
Yes
Check if new ceilings have been received
No
Revision
Information
Approval of revisions
Revise planning objectives
No
New ceilings ?
Yes

comparison. He can see that his faculty is not the only one suffering from resource scarcity, and he can see that one reason for others, possibly better achievements is that they have organized differently.

Some comments on strategic planning in a university system.

It may occur that the result of separating the strategic and the tactical planning is a much easier operating tactical resource allocation procedure. Hopefully this will be the result, however it would indeed be very naive to assume that all troubles wither away.

The intention has been to design a budgeting procedure which can be administrated, that is, to design a system in which the goals are reasonable well specified, so that others apart from the key decision-makers can work upon the issues.

Political actions, infights, organizational tensions, and conflicts will continue to be a vivid part of the life of the universities. Although many of these problems appear as resource problems, they are mainly problems relating to the organization's life and goals. These problems have to be solved by the members of the organization and not by the administration.

However most of the issues have a strategic nature because the way in which a conflict is solved influences the future states of the organization. The strategic planning is not performed by the formal planners and administrators but by the various committees working permanently or ad hoc in a university.

The committees are and will in the future be very important bodies, not only because the committees through the strategic planning establish the guidelines, but equally because the committees are the forum where both students and faculty participate.

A particularly important committee in the Danish university system is the study committee, which has an equal representation of students and faculty. Each of the major courses has its own study committee, and it is estimated that the total number will be around 100 when fully implemented. (See Hammer-Jespersen, Chapter 2). These committees are a result of the students' recent political activity, and the main purpose is to secure the students'influence on their study and the curriculae.

In the light of the current attitude of the students it is likely that the students will try to expand their power beyond the areas mentioned above. Although the students recently have gained a considerable amount of influence,the faculty sooner or later will react in order to secure their interests and goals in the long run.

The study committees can engage in two activities closely related to the tactical planning. One activity is a continuous evaluation of the courses of highest interest to the students as well as a revision of current courses. This activity could be an excellent guideline for the institutes when they plan their contributions.

The second activity, which in fact could be a part of the performance evaluation process is a careful revision of the courses particularly directed towards the possibility of a reduction of the number of courses having an almost identical content.

The revision process could include an option through which the study committee could deny performance credit to certain courses, being particularly bad one way or another.

Summary

This paper is initiated by a discussion of the differences between strategic and tactical planning. It is emphasized that strategic planning deals with the formulation of organizational objectives and long-range goals, and that tactical planning is the means by which the operation of the organization is controlled in order to reach these goals.

It is stressed that succesful tactical planning (budgeting) requires well specified strategic guidelines.

The following section deals with resource flexibility and uncertainty. It explains why these issues must be considered when planning, if the waste of resources is to be minimized. Means to reduce risk-exposure and to absorb risk are also discussed.

Total budgeting is claimed to be superior to marginal budgeting as a tool to secure the best overall achievements of the system. It is claimed that a proper design of a decentralized budgeting procedure can reduce the central requirement for data to a minimum.

Decision rules based upon the best satisfaction of future expectations are then briefly touched. An extensive coverage of this subject is given elsewhere in this report by Hammer-Jespersen and Rasmusen.

Decision rules based upon past achievements are then discussed as an effective managerial tool to be applied when central coordination has to be reduced to a minimum and/or when system behaviour renders it impossible to forecast the likely state of the future.

A payment decision rule is proposed and three different ways in which it can be applied are explained.

Following the analyses,a new budgeting procedure is proposed. It is explained how the strategic and tactical planning are separated. It is explained how the two-level planning technique can be applied in the annual allocation of resource ceilings and how this is accomplished in an iterative way.

Two-level planning is applied at the higher decision-making levels, where planning in terms of totals can be made and where reasonably accurate forecasts can be made.

The payment decision rule is proposed to be applied at the institute level where the uncertainty is larger and where the involved parties have means by which the course-choices of the students can be influenced and changed.

Information on what actually goes on in the system and how decisions are reached is essential if the members of the organization shall understand how it operates. The final section deals with the way in which information canbe disseminated in the course of the planning process, as well as how information must be gathered to make the model work.

Chapter 10

A POSTSCRIPT ON DECISION STRUCTURE

by

Dr Arne Jensen

When you try to assess the outcome of the studies carried out and the consequent methods developed, the heart of the matter must be whether these methods are suited for application under different conditions.

We are again facing the classical problem : "the past, the present, and the future". The studies were carried out with the support of analyses of organizations that are results of "the past".

What is considered important and less important is greatly influenced by "the present discussions of the situation".

The usefulness of the studies will depend on their ability to be implemented in an unknown "future".

In order to evaluate the flexibility of the ideas developed, I am going to discuss their applicability on "the university of the future", as I see it at the present.

General Views

Before going into details about such a future university system, I want to briefly state some of the fundamental and general rules that are characteristic of university systems today and in the future. Here you have to make the reservation that this is how I - having grown up as a member of the Danish society with its limitations - perceive them.

1) The second law of thermo-dynamics, that entropy increases in closed systems, also applies to a university system. However much energy a university system contains, its availability will tend to fall if it is a system left to itself. Entropy increases.

2) Some day it will run out of available energy and stop doing work unless

you are going to rearrange things,as quoted by David Allison ("Organization for Innovation" by J. A. Morton).

Maxwell drew the attention to the fact that "the second law of thermo-dynamics about the growth of the entropy could be infringed if such reorganization could take place by means of an intelligent creature called "the demon".

The First "Demon"

In order to survive, a university system must be able to pick up relevant ideas from and establish relevant problems for the society it serves. In the system there must be a "demon" that secures this. Otherwise the second law of thermo - dynamics - growth of the entropy - will destroy it in practice if not in a literal sense.

But two other possibilities do exist - possibilities that may not require such radical intervention in the daily function of the system as the first-mentioned "demon" seems to demand.

The second "Demon"

The university system has a "demon" that secures that its management at any time makes full use of our knowledge and ideas within management studies.

Although this other "demon" does not require quite that much from individual members of the university system, it is difficult enough to keep it alive within a university system that - according to its natural task - is sluggish.

Therefore, there is every reason to supplement it with :

A Third "Demon"

It looks up talent, i. e., either directly hires talented and creative people or sticks strictly to rules which enable you get people with great talent, creativity, and motivation for the goals of the university system in question.

If we do not wish to utilize one of these three "demons" we will have to find a fourth and/or fifth one that, with certainty, is able to break the laws of nature which also govern the university systems.

3) When organizing university systems we have to use our experiences with respect to carrying out scientific work and especially the methods we use when solving complex problems.

4) But we also have to build up an organization that is able to adapt to and

change with its environment. It is essential to make sure that the universities are able to adapt to and change with the environment and do it in such a way that we reach planned change and growths in these adaptive processes.

5) But how do we measure the "temperature" of the organization design and planned change of our university systems ? We have to go further than assessing the effectiveness. But considering the economic productivity and the human satisfaction within the system is not a sufficient criterion, either. We have to reach an ecological criterion containing more than the sub-total of these two criteria, and W.G. Bennis(1) has pointed out "the need for better criteria for judging the effectiveness of organization design and planned change, beyond those of economic productivity and human satisfaction, to the criterion of their ability to adapt and grow".

6) In order that this system constitutes a sound part of its environment a coupling between the system and its environment has to be carried through. Seen from an organizational point of view, this coupling has essentially been tied in with the coupling between a limited number of top people in the university management and representatives from the environment, whereas the coupling so crucial for the soundness, between the university system and the environment at the daily level, has been more or less left to the initiative of the individual person which is not always sufficient.

With the complex university systems prevailing today it is necessary to implement rules ensuring that such couplings organization-wise take place at a low level and that the couplings at a higher level between the system and environment do not restrain but promote the desire and ability of the system to live with such couplings to the society surrounding it.

This - when developing the university campuses with which we are living today - requires certain organizational measures of a more advanced kind than heretofore.

The building-up requires a structure that is able to couple together units geographically remote and able to overcome the communication problems prevailing among groups geographically or intellectually remote.

Where you have a genuine desire for establishment of communication, persons must geographically-wise be brought in close contact by means of joint tasks. Simultaneously, the scattered groups of people must stick to the aim of their central mother organization. They must have the support of the mother organization, both organization-wise and management-wise. The university system will profit from the establishment of a organizational closed democracy within its inner world. But the system has to be coupled together with the environment by means of a direct confrontation with reality, viz. the demand for a geographically close contact with the environment.

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(1) W.G. Bennis, Changing Organizations, Mc Graw-Hill Book Company, New-York 1966.

The direct, geographical contact between various specialists and the representatives of the environment by means of a joint project has preference to the organizational advantages obtained when completely centering persons with mutual interests - which very often is the result of a university campus.

An organization able to live up to all these demands will be humming with realistic ideas, realistic problems and easing the job of the "demon" that is to secure the persons of high talent within the university system and to see that proper man is in proper place.

Specific Views

Within this view the decision structure of the university system has to make sure that it fulfills its responsibilities with respect to at least the following six tasks :

1. Establishes a contact surface to the ministry.
2. Establishes a contact surface to society.
3. Establishes policies for the student body.
4. Establishes policies for non-academic personnel.
   Establishes policies for the two groups of academic personnel i.e.:
5. That part of the academic personnel whose goal it is to acquire scientific methods, partly to make sure whether they are creative and in the end able to prove their scientific abilities, and
6. That part of the academic personnel who have already proved their creativity and scientific abilities.

Re 1. To prove to the authorities that the aimed at goals have been reached, and to formulate future goals within the areas of education, training with respect to scientific methods, incentives for creativity and the carrying through of scientific work and, finally, the ability to - in due course - advise the society of the results obtained.

Re 2. To make sure - possibly by means of an organizational coupling between the university and society - that at all times a dialogue is taking place with society where the university staff, by useful confrontation with reality, utilizes already obtained results and gets inspiration for further research and, finally, gets the courage and strength to do its utmost in order to get the results recognized in spite of the scepticism of the environment - no matter whether this scepticism is named impossibility or uselessness.

Re 3. To support those persons-no matter whether young or old - who want to gather knowledge by letting them get an insight into the way scientific methods are carried out, and by helping them to become familiar with the tools to be used when they want to utilize immediate or later acquired knowledge for advancement of their intentions within their specific areas of interest.

Re 4. To establish a secure place of work with possibility for taking pleasure in both small and big things connected with the work.

Re 5. To establish the security and the pleasure of work that partly ensures that they are able to do their utmost, and partly sees to it that they, even if they are not able to realize their goals, leave the place of work with a background that will open doors for them elsewhere.

Re 6. To give them security, pleasure of work and reasonable support in order for them to realize their goals, whether one believes in them or not.

The research worker's meeting with the student during the process of learning will very often, by means of disclosing lack of knowledge, create incentive for further work leading to a systematizing and stabilizing of already obtained results which will prove to be useful for further research.

When, during the process of learning, a dialogue between two parties is taking place it will, furthermore, create an indirect contact surface with the environment - a surface that is larger than the research worker as an individual person will ever be able to create. This, although the contact surface may be incomplete, very often causes stimulation and creativity.

One should not underestimate the indirect effect of the research worker's observations of reality through a group of students. In the same way, one should not underestimate an incomplete version of the research worker's working methods, use of tools, and strategy, and one should be very careful not to overestimate the importance of the smooth fascile version of already acquired knowledge.

Measures

I have learned that a small group of m persons, for instance 5 - 8 people, in many respects will achieve the best results, and I take the liberty of generalizing that one representative very rarely is able to - in a fruitful way - represent the viewpoints of about 10 people or groups when each possesses his own individuality.

On these assumptions the organization requires a number of levels that at least are equal to logarithm N/logarithm m, covering a system of N persons or groups through committees with representatives of each. For the mentioned m equals 10, a number of levels bigger than logarithm N is reached. For N = 1000 you get 3, for N = 10 000 you get 4 levels in the decision process, which it should give reasonably direct communication. If the transfer of information is weakened through the levels, this has to be counter-weighed against the weakening obtained by larger groups in fewer levels.

Data

The application of quantitative planning techniques often leads to a severe lack of reliable data, which implies that the planning results often are of less value because of a prevailing uncertainty.

It is of great importance to realize that one of the most effective political weapons within large systems is the willingness to produce and provide relevant data for the rest of the system.

Much of the current lack of data within the university system is due to the fact that few have found it of any value to collect the data, when its use is not apparent.

It is important that each sub system does see the advantages of collecting and submitting data, if the outlined planning models shall ever be a useful tool in the day-to-day operations. This work should be carried out around a database, which can be accessed from all levels. Those who do not cooperate in the gathering, or who submit heavily biased data must be made to realize that, although they may be able to make short-term gains, the long-term effect will turn out to be more negative than positive.

Attained Decision Structure

One possible form of organization is a project-orientated organization where the projects are either educational courses or research projects or coupling projects between the university and the environment.

On this basis one must imagine a university system with separate decision points for the following four areas : education, research, coupling with environment, and operation. Each of these areas will cover a system of decision points in several levels in which the single case is going to start at the lowest level covering all people influenced by the case and, finally, finish at a level not too far from the starting level. Each area needs a vice president who looks after the structure of the organization, and the rules applied within it, in order to adequately fulfill the university system's goals.

The four areas are covered by one senate or a konsistorium which gives advice to the president about long range planning, general personnel policies, investments, and negotiations with ministries and other public authorities. Besides the economic and human factors the senate and the president also supervise the ecologic development of the system. The senate has to carry through the results of these negotiations including the society's requirements to the system.

It is supposed that the groups represented in the given decisions are not able to majorize each other in the decisions influencing their life. It is further supposed that the decision point uses a system of standing and ad-hoc committees for its work to assure the same quality and attitude in these matters as in the education and research work, i. e., a greater use of the scientific strategy applied to the solution of great, complex problems.

It is also supposed that each case in a decision point at least is going to be handled in two meetings assuring that the administrative system, not later than during the second meeting, is able to attach the case with its consequences directly and indirectly for the university system and its personnel.

Application of Hammer - Jespersen's Simulation Model, Chapter 6

In the simulation model in Chapter 6 with the mathematical outline Hammer-Jespersen has shown that today it is possible and administratively realistic to carry through calculation of consequences of action in the daily routine. The costs for these calculations are so low that it is possible to use them in the above mentioned required attached illustration of consequences of cases brought into the decision system.

This effectiveness will influence the kind of communication for the decision organ and its ability to act. In this way, it will itself, for a given decision structure, decentralize the power within the university system in question. During a short span of time one obtains information on the effect of various viewpoints and actions, and the attention is concentrated on the more important parts of the decisions. In the same way, the information on the real conditions within its own areas and within the areas of other decision organs will lead to a stabilization of the development towards long-term dispositions, with those advantages for the system as this will involve.

Application of Hans Jorgen Rasmusen's Decentralized Planning Model, Chapter 7

The work of Hans Jørgen Rasmusen on decentralized planning, Chapter 7, and the mathematical outline, has shown that it is today realistic to introduce such a system at the planning level, i.e. the level of the senate in the previously mentioned decision system, in order to allocate resources to lower levels of the system over a period of years.

The model will respect the constraints in the university under consideration - both budgetary and real constraints. It also naturally satisfies fixed policies such as agreements with the different unions, as well as externally specified administrative or political requirements, which are so well described by Jens N. Christiansen in Chapter 4, on budgeting, economic management and planning.

The model uses as input a series of parameters related to the present situation and its development through a series of given forecasts. This can automatically be drawn from Hammer-Jespersen's simulation model, or after careful study of Hammer-Jespersen's model be fixed by the planning authority. The model delivers as a supplement to the concrete allocation of money, people, and material a set of so-called shadow prices which are very useful tools in the discussions with the surrounding and ministerial levels, but even more important in the internal discussions at lower levels where one has to live with the given resources and formulate new policies for the periods to follow.

The selection of model constraints is of paramount importance in the design of the model. Constraints and parameters have to be carefully discussed and adjusted to the university or faculty system under consideration. This adjustment ought to be carried through under the auspices of the planning authority going to use it. In its given form it has not yet been through such a procedure, even in the case of the University of Copenhagen which has been the basis for this formulation. One possible revision procedure is outlined by Rasmusen in Chapter 9.

The decentralized planning model in its general form will even be applicable to higher decision levels than the level of the senate. At the level of the ministries it can be used as a means to allocate resources to universities or regions. However, before it is applied to this problem a careful adaptation, as well as experiments, must be carried through by the authority who is going to use it as a tool in the annual budgeting.

Both the simulation model and the decentralized planning model assume that reasonably accurate predictions of the future can be made available; the more uncertain the data is, the less valuable are the results obtained.

In Chapter 9 in the development of a decision-making process, Hans Jørgen Rasmusen has been dealing with these problems. In cases where the uncertainty is pronounced it is proposed to apply a dynamic decision rule, in which the last years achievements are the main basis for the current resource allocation.

This decision rule cannot be assumed to be applicable for major long-range decisions, but it can serve as a useful tool when dealing with the subsystems.

In times where large changes and problems of adaptation do exist between the universities and their environment, it is of paramount importance for all involved parties to continue the work which has been initiated by these studies in institutional management of the higher education.

The decision structure and its associated administrative systems, which we have inherited from the past, can no longer provide a sufficiently rapid adaptation, if a reasonable level of stability is claimed.

The verbal debate is too slow a means to solve the problems if a smooth running system is desired in the rapidly changing and growing university sector.

It is necessary to introduce new rules of governance and new administrative systems.

The Danish CERI project contributes a set of models and procedures for this very purpose.

Appendix 1

ENGLISH SUMMARY OF WORKING REPORTS AND PAPERS

(June 1971)

CERI-Report I : Hans Jørgen Rasmusen, Analysis of the Social Science Faculty Budgeting. Jan. 1970.
(Analyse af Det Rets- og Statsvidenskabelige fakultets budgettering) in Danish, pp 26.

The report analyses how the social science faculty develops its budget proposals and how it allocates resources made available.

The study is based upon data covering the period 1967-1970. The study shows among other things that the social science faculty only plans for a relatively small tenure faculty, mainly full professors. Almost all teaching is performed by non-tenure hourly paid teachers.

Research projects do not appear to have any high priority, and what goes on is generally one-man ventures.

CERI-Report II : Niels Hammer-Jespersen, The Administrative and Academic Structure of the University of Copenhagen. Feb. 1970. (Notat angående Københavns Universitets administrative og kollegiale organer) in Danish, pp 12.

The report gives a short description of the formal distribution of administrative and academic power in the present university system.

It emphasizes the lack of cooperation between the academic and budgetary planning. The report finally compares a proposed university administration law with the present one. The main feature of the new law is that both academic and administrative responsibility is concentrated in the office of the university-president.

CERI-Report III : Niels Hammer-Jespersen, Analysis of the Natural Science Faculty Budgeting, March 1970.

(Analyse af Det Matematiske-Naturvidenskabelige fakultets budgettering) in Danish, pp 44.

This report is an extensive study not only of the way in which the natural science faculty determines its resource requirements, but also a study which gives statistical information on manpower structures and teaching duties.

The study shows that the natural science faculty uses rigid rules when it is calculating manpower requirements, and that it tries to maintain a fixed manpower structure.

The manpower structure indicates that a large number of research activities are undertaken and that high priority generally is assigned to research activities.

CERI-Report IV : Hand Jørgen Rasmusen, A Proposal for a Decentralized Budgeting Procedure, May 1970. (Forslag til en decentral budget lægnings-procedure) in Danish, pp 37.

This report deals with some possibilities of developing a planning system. The report continues hypothesizing one possible objective function and the constraints within which a solution should be located.

The report presents a model based on decentralized planning and it is shown how the planning problem can be formulated as a linear programming problem.

CERI-Report V : Niels Hammer-Jespersen, Cash-flow Study at the Natural Science Faculty, June 1970. (Analyse af regnskaber for institutterne under det Matematiske Naturvidenskabelige fakultet ved Københavns Universitet, finansårene 1967/68 og 1968/69) in Danish, pp 35.

This report attempts to study the cash-flow through several departments of the natural science faculty. The cash-flow consists mainly of accounts which constitute the research overhead. The use of these resources might therefore reveal some aspects of the research activity.

It is found that approximately 80 % of the research support is spent in the two last months of the fiscal year. The study also reveals that many departments maintain large inventories of materials.

It is finally argued that large savings might be expected if more economic inventory policies are considered.

CERI-Report VI : Jens N. Christiansen, Some Thoughts About Decision Variables and Decision-levels. May 1970.
(Nogle betragtninger over beslutningsniveauer og budget variable) in Danish, pp 9.

The report is an internal working-paper dealing with some objectives for the educational system as seen from the Ministry of finance.

CERI-Report VII : Niels Hammer-Jespersen, Some Ideas Behind the CERI-project, May 1970. (Notat om udgangspunkter for CERI-projektet på basis af betænkninger og materiale i Undervisnings-ministeriet) in Danish, pp 25.

The report is an internal working-paper dealing with some of the ideas and objectives behind the participation of the Ministry of Education in the CERI-project.

CERI-Report VIII : Ray Jurkovich, Notes and Suggestions on the University of Copenhagen's Structure, June 1970, in English, pp 39 and Addendum pp 6.

This report is a sociological study on the structure of the University of Copenhagen. The report is based upon interviews with persons at various positions in the University system. The study shows that much difficulty appears because large parts of the administration are based on inherited traditions. The report proposes that the University reorganize its committee system, in order to give the committees better defined working areas.

It is finally proposed that faculties and departments should be permitted to reorganize their structure according to the situation.

CERI-Report IX : Niels Hammer-Jespersen, Description of the Data File System at the University of Copenhagen. September 1970.
(Beskrivelse af informationssystemet ved Københavns universitet) in Danish, pp 13.

The report is a brief description of the present data-base system at the

University of Copenhagen. The University is at present maintaining two separate data-systems. One is an academic file system containing information about faculty and other employees, enrolled students etc.

This system is based on an EDP-system. The other file system contains the economic administration of the University. This system is operated in a traditional manual accounting system.

This state of affairs make it almost impossible to obtain up-to-date information from the latter system.

CERI-Report X : Hans Jørgen Rasmusen, On Decentralized Planning in a University System, Aug. 1970, in English, pp 29.

This paper deals with some problems encountered when introducing planning techniques in a university system.

Centralized and decentralized planning is considered, and it is shown how decentralized planning under central control may lead to an effective management system.

The planning problem is then formulated as a linear programming problem using Kornai-Liptak decomposition technique.

Numerical data is applied using data collected from the University of Copenhagen as part of a joint project between the Danish Ministry of Education and OECD, Paris.

The paper was presented at the Advanced Study Institute on Statistical Models in Education and Training, London 1970.

CERI-Report XI : Jens N. Christiansen, Economic Budgeting - Some Thoughts July 1970. (Økonomisk Budgettering, nogle synspunkter) in Danish, pp 15.

This paper discusses the basic economic terms and the traditional ideas behind the budgetary preparations in public and private enterprises. The paper continues to discuss the investment criterias and ends up with an introduction to cost-benefit analyses.

CERI-Report XII : Dr. Jonathan Halpern, Research in the Administration of a University. Comparative Remarks on the Universities of Copenhagen and California. Nov. 1970. in English pp. 17.

This paper is a comparison between the current research activities in Berkeley and Copenhagen. The paper clearly states the very large and marked differences between the scale of activity in California and Denmark. It is shown that this difference is not entirely a result of the fact that management sciences were introduced in the United States earlier. Differences in the organizational structure and the general attitude towards planning is a major cause of this state of affairs.

CERI-Report XIII: Niels Hammer-Jespersen, A Simulation Model for a University. March 1971. (Simulations-Model for et Universitet) in Danish pp 80.
English summary of the mathematical model pp 8.

This paper gives a very comprehensive description of a simulation model, which has been designed as a tool for providing information on the future resource demands, which are necessary to maintain the current structure or currently planned structural changes. The simulation model is built around a student- and a faculty- flow model. These flow models compute stocks of students and faculty at the different levels and grades, thus permitting a computation of resource demands and supply.

The model is calibrated by using data from the past 10 years, for the estimation of technical coefficients and transition probabilities.

CERI-Report XIV: Hans Jørgen Rasmusen, A Decision Model for Resource Planning. March 1971. (En beslutnings-model for ressourceplan laegning) in Danish pp 37. English Abstract.

This paper attempts to analyse some of the conditions which must be satisfied in an organization, if decision influence should be delegated to members of the organization.

The paper initially stresses the importance of separating the tactical and strategic planning. It is further claimed that the main reason behind centralization of decisions is the central decision makers' uncertainty of the willingness and ability of the decentral units to fulfill the goals of the total organization.

The paper continues with an analysis of the common resource decisions in a university system. It is argued that risk can be reduced by changing from a marginal to a total resource planning procedure, as well as by a careful specification of performance criterias.

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